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SILO 1 AND 2 PROOF OF PRINCIPLE PROJECT

Final Report

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LIST OF ACRONYMS

ACFM	Actual Cubic Feet Per Minute
APC	Air Pollution Control
ASTM	American Society for Testing and Materials
AWWT	Advanced Wastewater Treatment
BAT	Best Available Technology
CELS	Corning Laboratory Engineering Services
CFR	Code of Federal Regulations
CM	Cyclone Melter
CMS™	Cyclone Melting System
CRV	Counter Rotating Vortex
CSC	Comprehensive Safety Compliance
DOE	Department of Energy
DSF	Demonstration Surrogate Feedstock
DS	Demonstration Surrogate
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FDF	Fluor Daniel Fernald
FIBC	Flexible Intermediate Bulk Containers
FS	Feasibility Study
FWE	Foster Wheeler Environmental Corporation
HEPA	High Efficiency Particulate Air Filter
MSDS	Material Safety Data Sheets
NEPA	National Environmental Protection Act
NTS	Navada Test Site
OSHA	Occupational Safety and Health Act
PFD	Process Flow Diagram
PLC	Programmable Logic Controller
POP	Proof of Principle
PPM	Parts Per Million
Q/A	Quality Assurance
Q/C	Quality Control
RCRA	Resource Conservation and Recovery Act
RCS	Radon Control System
S/R	Separator Reservoir
S1	Silo 1
S2	Silo 2
SCFM	Standard Cubic Feet Per Minute
SRD	Systems Requirement Document
TC	Toxicity Characteristics
TCLP	Toxicity Characteristic Leading Procedure
TPD	Tons Per Day
TSS	Total Suspended Solids
TTA	Transfer Tank Area
U-PARC	University of Pittsburgh Applied Research Center
UTS	Universal Treatment Standards
VOC	Volatile Organic Compounds
VPSA	Vacuum Pressure Swing Absorption
WAC	Waste Acceptance Criteria
XFR	X-ray Diffraction

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1.0 EXECUTIVE SUMMARY

1.1 CONTRACTS KEY COMPONENTS

The objective of the Proof of Principle (POP) Program Demonstration being conducted by Vortec for Fluor Daniel Fernald (FDF) is to generate technical data on the Cyclone Melting System™ (CMS™) performance for inclusion in a future feasibility study. This feasibility study will be used to establish the acceptability of each of four candidate technologies that are capable of remediating the Silo 1 (S1) and Silo 2 (S2) residues presently store at Fernald.

The four key elements of the Vortec proof of principle program are as follows:

1. Preparation and analysis of the S1, S2, and Demonstration Surrogate (DS) materials.
2. Development of the glass formulations to vitrify the DS, S1 and S2 residue surrogates.
3. Completion of a 72-hour proof of principle test at the Vortec Pilot Test Facility to demonstrate the CMS™ technology's capabilities.
4. Preparation of a preliminary design and cost estimates for a full-scale CMS™ plant to process 6,780 cubic meters of tank residue in 36 months.

Vortec has completed all four items and this report will present the data generated during these activities.

1.2 FORMULA DEVELOPMENT

FDF defined the chemical composition of the Demonstration Surrogate and Vortec Corporation defined the glass additives needed to prepare a feedstock suitable for vitrification. (A feedstock is defined as the surrogate slurry combined with the glass making additives necessary to form a glass when processed in the CMS™). Vortec prepared laboratory samples of the DS slurry and submitted them to FDF for analytical verification prior to the 72-hour test. As the S1 and S2 surrogate materials were defined and provided by FDF, laboratory tests established the glass making additives needed to produce glass that passed the Toxicity Characteristic Leaching Procedure (TCLP) and Universal Treatment Standard (UTS) specification. After the laboratory investigations were completed, Vortec prepared the DS, S1 and S2 slurry; made glass in the laboratory; took samples; had the glass analyzed for TCLP and oxide composition; and submitted the samples and analytical results to FDF. The required amount of glass for archival purposes was also transmitted to FDF.

1.3 72-HOUR TEST

Vortec conducted a Proof of Principle test during the week of November 30, 1998 at its High Temperature Test Facility located at the University of Pittsburgh Applied Research Center (U-PARC) in Harmarville, PA. During the 72-hour test, approximately 18,469 pounds of slurry were processed to produce approximately 5,900 pounds of glass (glass product was dried and weighed post-test to establish total production). Vortec retained the services of Horizon Environmental, Inc. to assure that sampling conducted during the test followed EPA's protocols. Samples were shipped to Corning Engineering Laboratory Services (CELS) and to FDF for analysis as defined in Vortec's, FDF approved Quality Assurance (Q/A) and Work Plans. The combined data from the POP test are summarized in this report; that is the system performance, mass and energy balance around the CMS™ components, glass analysis, TCLP results, and glass partitioning results (establishing the portion of an incoming element or compound that is retained in the glass). Supporting data are included in the appendices to this report and in a separate data deliverable package. (Fernald Submittal No. 407220-2241-C4-001)

Test operations were scheduled for 72 consecutive hours to demonstrate a system availability of at least 95%. The test processed approximately 18,469 pounds of the DS slurry. An average daily surrogate slurry processing rate in excess of the 2,600 kg was demonstrated during each of the three 24 hour periods. Vortec performed the test as scheduled, processed all of the demonstration slurry, took all of the samples required by the approved work plan, and demonstrated a system availability for the U-PARC test facility of 99.58%. Representatives of FDF, Department of Energy (DOE), EPA-Region 5, State of Ohio-EPA, and the Critical Analysis Team representing the Fernald Stakeholders Group, witnessed the test. A list of attendees is provided in Appendix A.

The 72-hour test demonstrated the CMS™ technology's ability to process the Demonstration Surrogate in a 30% solid slurry form, and make a glass that leaches the TCLP heavy metals at a rate 50% lower than specified in the 40 CFR 261 regulation. The test was run in accordance with the work statement using the DS slurry. However, design studies being conducted in parallel with test preparations indicated that slurry feeding into the CMS™ on a commercial scale would not be feasible because the fuel requirement to vaporize the water contained in the slurry increased the flue gas volume beyond the capacity of the RCS carbon beds. The full-scale design configuration will require the drying of the slurry received from the Transfer Tank Area (TTA) before processing in the CMS™. Dry feeding of material into the CMS™, after blending with any required glass making additives, is the standard operating procedure for the CMS™. This mode of supplying the feedstock to the CMS™ has been demonstrated on over 150 of the 166 tests previously conducted at U-PARC, and is the method used in the commercial application.

The test facility at U-PARC includes an Air Pollution Control System (APC) that consists of a partial quench followed by a wet electrostatic participator (WESP). The preliminary full-scale system design consisted of a partial quench followed by a bag filter followed by two stages of scrubbing. However, as with the drying and grinding operations in the feed preparation system, these APC components are well established commercial designs with their performance usually guaranteed by the manufacturer when processing materials with known properties. Given the short schedule and funding availability for this POP test, modification of the feed preparation system to demonstrate "conventional" water removal and the APC system to demonstrate conventional flue gas clean-up was considered beyond the scope of work.

The CMS™ system did process the DS surrogate (as a 30% solid slurry), made glass that passed the waste acceptance criteria, and ran continuously for 72 hours. Processing dry feedstock has been conclusively demonstrated over the last ten years of operation at the U-PARC facility. Drying the slurry received from the TTA with conventional technology, (i.e., centrifuges and heated screw dryers) is considered a demonstration test that will be conducted during detail design. In Vortec's opinion the POP test conclusively established the CMS™ as a viable technology for the remediation of the silo residue.

1.4 72-HOUR TEST RESULTS

TCLP results for the 72-hour test are given in Table 5-1 of Section 5 and indicate that the glass leached the RCRA metals at a rate lower than one half the rate published in 40 CFR 261. In addition, the glass appeared uniform and homogeneous, has a compressive strength of at least 50-psi, and is not classified as a hazardous waste by characteristic.

In general, the comparison between the concentration of a specific compound in the glass, when computed by summing a constituent in the slurry and the off-gas, and the concentration of the constituent measured in the glass by CELS are in agreement within 5%. Mass balance and glass analysis comparisons for the 72-hour test are summarized in Table 5-2 of Section 5.

Following receipt of the test data from the CELS Laboratories, Vortec prepared a test report documenting the performance of the CMS™. The test report includes the analysis of the influent and effluent streams, giving the concentrations of the constituents of the slurry feedstock as well as the plant's thermodynamic performance. The results are also presented in Section 5. The test report is included as Appendix B.

1.5 FULL-SCALE DESIGN

Concurrent with the proof of principle testing, Vortec/Foster Wheeler Environmental (FWE) produced a preliminary design for a full-scale plant capable of processing the 6,780 m^3 of residue found in Silo 1 and Silo 2 in 36 months. Vortec initiated the full-scale system design by conducting several trade studies to determine the best system configuration for processing the slurried tank waste while meeting the FDF imposed system design requirements. The most critical of these design requirements for the CMS™ was to keep the off-gas flow rate at approximately 500 ACFM. The initial system configuration proposed by Vortec would feed the slurry directly to the CMS™ reactor, recycle and oxygen enrich the off-gas, and clean a slip stream to prevent high levels of contaminant concentrations (principle concern was radon gas and CO_2 build-up). However, this initially proposed configuration of the full-scale plant resulted in excessive CO_2 concentration in the off-gas, caused by the need to provide the heat to evaporate the water contained in the slurry. The high CO_2 concentration was considered likely to adversely affect the radon control system's carbon beds. Also, the additional carbon bed capacity to handle the flue gas volume would impact the entire system life cycle cost.

A revised system configuration was established that removed the moisture from the slurry at lower temperatures using a mechanical centrifuge followed by heated screw dryers. The heated screws are indirectly heated and do not contribute an additional burden to the off-gas cleaning system. The dry feedstock is fed to the CMS™ melter in the same manner used with the Vortec commercial systems. Vortec has conducted 166 tests in the U-PARC facility with the majority of these test (approximately 150 out of 166) being conducted using dry feed arrangements. Vortec and FWE are confident that the drying of the slurry received from the Transfer Tank Area (TTA) is achievable and cite the 37 successful applications listed in Table 1-1, in which sludge type materials of various consistencies have been dried in commercial operations using heated screw dryers.

Table 1-1. Holo-Filite Screw Dryers Partial List of Commercial Installations

Material	Customer
Sludge	Waste Tech
Sludge	Delaware Container
Sludge	Haden
Sludge	Tier, Inc.
Sludge	US Army
Sludge	Western Environmental
Sludge	TRW Environmental
Sludge	Pacific Industrial
Sludge	Pipe & Drain (SV LTD – UK)
Sludge	Hoechst Celanese
Sludge, Gypsum	DuPont
Sludge, Laundry Waste	Aratex
Sludge, Municipal	EG&G
Sludge, Paint	Haden R&D
Sludge, Refinery	Prestech
Sludge, Refinery	Williams Pipeline
Sludge, Refinery	Waseco/Exxon
Sludge, Refinery	RETEC
Sludge, Refinery	Vanguard
Sludge, Sawdust	Burlington
Sodium Phenoxyacet	NIACET
Sodium Phenoxyaceta	NIACET
Soy Flakes w/H_20 & Hex	Dawson Mills
Soy Flakes w/H_20 & Hex	Dawson Mills
Soy Flakes w/H_20 & Hex	Dawson Mills
Stibnite Concentrate	Joy Australia
Stibnite Filter Cake	McNally
Terephthalic Acid	Barber Coleman
Terephthalic Acid	Barber Coleman
Tin Concentrate	UINSUR
Titanium-Sponge	Dow Chemical
Uranium Perurinate	Combustion
Uranium Yellow Cake	Exxon Nuclear
Wood Flour	Sanderson Plumbing
Wood Flour	Sanderson Plumbing
Wood Flour	Sanderson Plumbing
Wood Flour, Pine & Hard	Beneke

The off-gas leaving the separator reservoir enters the APC System consisting of an evaporative cooler to quench the off-gas to 450°F, followed by a bag-filter for particulate removal, two stages of scrubbing for SOx and NOx removal, and carbon beds for radon control (carbon beds are not part of the Vortec Design). Particulate removed in the bag filter has as its major constituents over 50% lead sulfate and 16% silicon dioxide, with the remaining material being oxides of sodium, calcium, and aluminum. This material will be recycled to the melter for inclusion in the glass. Vortec demonstrated this recycling technique under an EPA-SBIR Program in 1992.*

The glass product is water quenched to produce a glass frit and placed in FDF designed boxes for transportation to a repository. Alternatively, the production of a monolith could be accommodated, and is standard practice for melters used for the processing of high level radioactive waste in the nuclear power industry.

It should be noted that the full-scale design would utilize oxygen enrichment as an additional aid in reducing the flue-gas volume. Oxygen enrichment has been demonstrated in the Vortec Test Facility during 10 dedicated tests. Two specific tests were:

1. Soil Vitrification–Enrichment to 40-wt % for the purpose of demonstrating increased throughput at a fixed reactor size with oxygen enrichment. The affect on organics DRE was also investigated. These tests were conducted for the Federal Energy Technology Center.
2. Spent Pot Liner Processing–Enrichment to enhance carbon conversion. Local enrichment approached 100% O_2, overall enrichment in the 25–30 wt % range. These tests were conducted for a commercial client.

2.0 PROOF OF PRINCIPLE TEST DESCRIPTION

2.1 TEST OBJECTIVES

To assist the DOE and FDF in the investigation of alternative technologies for the treatment of low-level, radioactive silo residues, Vortec has performed a proof of principle test using its CMS™ test facility located in Harmarville, PA.

The overall objectives of the 72-hour proof of principle test were to demonstrate the suitability of Vortec's CMS™ technology for the treatment of silo residue at Fernald and provide experimental data for a preliminary design of a full-scale remediation facility. The testing employed a non-radioactive DS that has key chemical/physical characteristics of the actual silo residue.

*Reference: EPA SBIR Program Phase I "Innovative Concept for Recycling Heavy Metal Carryover into an Advanced Hazardous Flyash/Dust Vitrificaiton Process." Final Report submitted to the US EPA RD-675, Washington, DC December, 1992.

Specific Vortec objectives for the 72-hour test were:

1. Process 2,600 kg (30 wt % solids) of demonstration surrogate slurry per 24 hour period for a total of 72 hours of continuous operation.
2. Obtain sufficient data to allow FDF to evaluate the potential of the CMS™ to process Silos 1 and 2 residue on a full-scale basis. These data include system mass and energy balances, demonstration of continuous operation, component performance, and system availability.
3. Produce glass for subsequent analysis with respect to actual composition and leachability to demonstrate that it can pass the established waste glass acceptance criteria.
4. Obtain preliminary data with respect to flue gas handling requirements through stack sampling and analysis (these data are also needed to establish partitioning).

The test was conducted feeding slurry composed of 30% DS surrogate and 70% water as stated in the FDF Work Statement. The slurry was blended with glass making additives and fed to the CMS™ for vitrification. The air pollution control system at the test facility consisted of a partial quench system followed by a WESP. The POP test in the Vortec test facility met the following stated objective of the FDF Work Statement, "...... the program shall provide data that indicates whether the CMS™ produces a treated surrogate that meets the performance criteria." The equipment used in the test facility is representative of the CMS™ equipment that would be used in the full-scale design.

The pre-drying of the surrogate was not demonstrated since the FDF Work Statement required slurry feeding, and the decision to use dry feeding at full-scale was made late in the design phase. However, dry feeding of material into the CMS™ is a well demonstrated technique, and drying and grinding will use well established equipment whose performance will be experimentally demonstrated in the final design phase.

Vortec also provided glass formulations for the S1 & S2 residue compositions provided by FDF.

2.2 72-Hour Test Preparation

Vortec modified its test facility to provide a slurry feed preparation and delivery system. These modifications consisted of installing a 2,000-gallon mixing tank with an agitation system and two 200-gallon population tanks with agitation systems for blending of slurry and glass additives. Vortec developed injectors for use with the CMS™ system, and these injectors are usually tailored to the particular material being fed. Two injectors were developed to meet the needs of this test. In addition, modifications to the reactor's lid were required to accommodate the new design. Cold flow and hot tests were conducted on the slurry feed system and injector, using limited amounts of slurry, for shake down and check out prior to the 72-hour test.

Simultaneous with the modifications to the facility, laboratory testing was conducted to develop the DS and to establish a glass making formulation that would produce a glass having the specified characteristics. The DS was first prepared in the Vortec laboratory, and the preparation procedure was witnessed and approved by FDF. Samples of the 70% water-30% solids slurry were prepared and sent to FDF for verification.

The final task to be completed in preparation for the test was the mixing of the 18,469 pounds of the demonstration surrogate. Water, Bento Grout™, and a portion of the magnesium phosphate (soluble in water) were mixed in the 2,000-gallon tank September 23, 1998, to allow time for the Bento Grout™ to sufficiently hydrolyze in anticipation of completing the mixing operation the following day. However, there was a delay in completing the mixing until November 11, 1998. (The delay was caused by an insufficient lead leaching rate from laboratory samples previously sent to FDF). Samples from the completely mixed DS slurry, the material to be processed during the 72-hour test, were sent to FDF for analysis on November 12, 1998. The POP test was conducted during the week of November 30, 1998.

2.3 Quality Assurance

Vortec defined, implemented, and maintained a Q/A plan during the POP test. As stated in this plan, the quality objective of the POP test was to assure that the data generated was obtained in a systematic and planned manner, that accepted quality standards were employed, and that the use of these standards was documented. Table 2-1 is a summary of the principal Q/A requirements and the date that the requirement was met.

3.0 TEST PROCESS DESIGN AND PROCEDURE

3.1 Surrogate Preparation

The following sections discuss the preparations and analyses of the surrogates and surrogate slurries that were prepared during this program.

3.1.1 Procurement of Surrogate Ingredients

Prior to completion and acceptance of the Work Plan and the Q/A-QC Plan, Vortec purchased the necessary compounds (ingredients) for the preparation of the surrogate slurries. Batches of the slurries were prepared according to the instructions provided by FDF.

Certifications, assays, and Material Safety Data Sheets (MSDS) were obtained with each material received from the supplier. Sieve testing followed ASTM Method D422, and the moisture associated with the samples was determined according to ASTM standard D2216. The non-water soluble compounds were characterized by a sieve analysis to ensure that the particle size and distribution of the particle size were consistent with FDF's specifications. These tests verified the data provided by suppliers on product data sheets used in the selection of the materials. The water-soluble compounds dissolved in the slurry; thus, their particle size was not significant. Copies of the MSDS, assays, certifications, and particle size analysis were provided to FDF, as shown in Table 2-1 item 3b.

Table 2-1. List of Q/A Requirements

Item No.	Requirements	Tasks	Date Occurred
1	Prepare QA Plan.	a. Document Results of Review of the QA Final Draft.	9/10/98
2	Prepare Work Plan.	a. Document Results of Review of Work Final Draft.	9/10/98
3	Procure Surrogate Materials.	a. Audit Documentation of the Characterization of the Surrogate Materials. b. Review documentation of characterization and send to FDF.	9/14/98 9/14/98
4	Surrogate Preparation.	a. Validate Surrogate Preparation Procedure. b. Validate Laboratory Calibration Procedure. c. Review support documentation sent to FDF.	9/15/98 9/15/98 9/21/98
5	Develop Treatment Recipes.	a. Validate Glass Preparation Procedure. b. Validate Laboratory Calibration Procedure. c. Review support documentation sent to FDF.	9/11/98 9/15/98 9/21/98
6	Slurry Feed System.	a. Design Review Documentation. b. Document System Performance.	9/24/98 10/16/98
7	Injector System.	a. Document Cold Testing. b. Document Hot Testing.	10/16/98 10/16/98
8	Preparation of Feedstock for the 72-hour Test.	a. Document Slurry Preparation-FDF present at U-PARC. b. Review Sampling Contractors' Procedures. c. Review Sampling Contractors' QA Documentation. d. Confirm Shipment to FDF Laboratory.	11/9/98 11/9/98 11/9/98 11/24/98
9	72-hour Test.	a. Review Sampling Contractors' Procedures and Calibration (Glass and Other Effluents). b. Review Sampling Contractors' Procedures and Calibrations (Flue Gas). c. Review Vortec Test Procedure and System Calibrations. d. Review Sampling Contractors' QA Documentation. e. Confirm Shipment of Samples to CELS Laboratory.	11/24/98 11/24/98 11/24/98 11/24/98 12/15/98
10	Test Report.	a. Review and Document Test Report Final Draft.	3/15/99
11	Full-scale Design.	a. Review and Document System Design Requirements. b. Document Design Review of the Full-scale Preliminary Design. c. Review Full-scale Preliminary Design Report.	1/14/99 1/14/99 1/14/99
12	Final Report.	a. Review Final Report.	4/29/99

3.1.2 Surrogate Preparation and Characterization (Laboratory)

Although the definition of the DS, S1, and S2 surrogates were received from FDF at different times throughout the program, the procedure used to develop the surrogate, form a slurry, and conduct testing in the laboratory is essentially the same for all three surrogates.

Vortec prepared the DS surrogate in the laboratory from materials that were purchased for the 72-hour test. However, FDF, late in the program, decided to purchase the materials for S1 and S2 surrogates thereby assuring that the materials would be uniform across the program contractors. Once prepared, the surrogate was characterized with regard to moisture, density, and TCLP for lead. The S1 and S2 materials were shipped to Vortec in a premixed condition. See Section 5.2.1 for a more complete discussion.

3.1.3 Slurry Preparation and Characterization (Laboratory Scale)

The preparation of the slurries was initiated by first measuring into a beaker the amount of water required to achieve the 30% solids content in the final product. The water-soluble chemical compounds were added and allowed to dissolve completely into the water. The Bento Grout™ was slowly added, to allow for the particles to become completely dispersed into the solution. Then the remaining dry chemicals were added. Finally, the organic components (kerosene and tributyl-phosphate) were added and mixed into the slurry. When the slurry became too thick to stir with a stirring rod, mechanical means were utilized. Once completely mixed, the slurry was allowed to age for at least 24 hours prior to characterization so that the bentonite and other compounds hydrolyzed and approached equilibrium.

The moisture content of the slurries containing 30% solids was determined by a weight loss on drying at 105° C (220° F) for 24 hours in an oven (ASTM Standard D 2216). The density of the slurry was determined by weighing a known volume of the slurry and dividing the weight by the volume of the slurry. The slurry volume was determined by filling a graduated cylinder with the slurry. The leaching behavior of lead in the slurry was characterized by a TCLP test. The pH of the demonstration surrogate was 9.52. The moisture content at the plasticity limit was determined to be 45%. The laboratory-prepared DS slurry had a lead concentration in the TCLP leachate less than the 800-PPM requested. FDF and Vortec reviewed the situation, and the initial formulation of the DS was changed. Final DS slurry composition is given in Table 3-1. The formulations in Table 3-1 includes all of the material in the surrogate, including the Bento Grout™, but does not include the glass making additive.

Since FDF supplied the material for the S1 and S2 surrogates in a premixed form, S1 and S2 surrogates were not developed by Vortec.

3.1.4 Glass Formulations

Initial crucible melts in the laboratory indicated that adjustments in glass chemistry were needed. Once a quality glass was produced (ascertained by appearance and melt characteristics) it was sent to Blue Marsh Laboratory, in Douglasville, PA, for TCLP evaluation. If the glass passed the TCLP criterion, the remaining criteria established by FDF (See Table 3-2) were evaluated and the formulation was either accepted or further modified.

A major objective in the laboratory scale development was to produce a glass that passes the leaching requirements for lead and simultaneously had a low processing temperature. Reducing the temperature decreases the volatilization of lead and maximizes the waste loading in order to decrease the amount of material that ultimately requires storage/disposal. The Vortec glasses generally contained 85% slurry (at 70% water) with 15% glass additives. The initial goal was to have approximately 70% of the oxides in the final vitrified product being derived from the waste. (Experimentally achieved loading was approximately 85%, as shown in Table 5-6).

Table 3-1. Demonstration Surrogate Formulation (Basis: g/100 g)

Compound	Formulation for TCLP
Na_2HAsO_4	0.08
$BaSO_4$	2.26
Na_2CrO_4	0.07
Fe_2O_3	0.70
$Mg_3(PO_4)_2$	0.52
$NaNO_3$	0.28
NiO	0.12
PbO	1.57
$PbCO_3$	1.82
$PbSO_4$	0.73
Na_2SeO_3	0.04
SiO_2 Mix (See Below)	
V_2O_5	0.02
ZnO	0.00
Tributyl Phosphate	0.25
Kerosene	0.25
Diatomaceous Earth	0.51
Feldspar	5.06
Bento Grout™	2.57
H_2O	69.65
SiO_2 Mix	
Coarse SiO_2	5.74
Fine SiO_2	5.22
Fumed Silica	2.53

Table 3-2. FDF Criteria for Acceptance of Glass

Appearance:	Uniform and homogeneous.
Compressive strength:	50 psi
Standing liquids:	None
Leach Rate:	50% of 40 CFR 261 requirements.
Limited dusting:	Treated surrogate contains less than 1% particulate with diameters of 10 microns or less.
Not classified as a hazardous waste:	Passes TCLP test as defined in 40 CFR 261.

3.1.5 Demonstration Surrogate Preparation for the Proof of Principle Test

Vortec initiated the preparation of the DS surrogate on September 23, 1999. On September 24, 1998 FDF requested discontinuing of mixing until corrective action could be established since the demonstration surrogate, prepared by Vortec and others, did not leach lead at the required rate.

Table 3-3 lists the ingredients in the demonstration surrogate slurry. DS slurry preparation was initiated by introducing 90% of the deionized water (11,600 lbs) into the 2,000 gallon slurry storage tank. The volume of water to be introduced into the tank was first calculated. Then the desired level of the water in the tank was calculated based on the tank dimensions, and a level marked on the inside wall of the tank. A deionizer was installed in the water supply line, and water was then introduced into the tank until it reached the marked level. The agitator in the tank was then turned on prior to introduction of the other slurry ingredients.

The Bento Grout™ [Ingredient #21] was the first solid material introduced into the water in the slurry storage tank. It was slowly added and slaked onto the surface to avoid large clumps dropping into the water. After all the Bento Grout™ was added, one barrel of magnesium phosphate ($Mg_2(PO_4)_3$) [#5] [sixty-two percent of the total $Mg_2(PO_4)_3$ that was to be in the surrogate] was added to the mixture.

Preparation of the 72-hour test surrogate resumed on November 9, 1998, with FDF representatives witnessing the preparation. FDF had concluded that the low Pb leach rate from the validation surrogate was due to the addition of $Mg_2(PO_4)_3$. Therefore, the decision was made to continue preparation of the 72-hour test surrogate by adding all the remaining ingredients except for the additional $Mg_2(PO_4)_3$. The surrogate would then be sampled and analyzed by FDF, and FDF would then decide what modifications, if any, would be made to the surrogate composition.

The water soluble compounds [#1, #3, #6, #11] were weighed out and added to the mixture in the 2,000 gallon tank. This was followed by the addition of a mixture of the fine silica [#13] and organics [#17, #18]. The fine silica and organics were first mixed together by adding about 1/5 of each ingredient into five 55 gallon drums and rotating the drums for 15 minutes on a motorized drum rotator. The contents of the drums were then added to the mixture in the slurry tank.

Following the addition of the fine silica and organics, powdered lead sulfate ($PbSO_4$) [#10] was delumped and added to the slurry. The delumping was accomplished by putting the $PbSO_4$, 3/8" steel mixing balls, and deionized water in a Nalgene container, placing a cover on the container, and rotating the container on the drum rotator for one hour. The contents of the container were then sifted through a 50 mesh screen to remove unground particles and the mixing balls. The unground particles and mixing balls were then returned to the container and again rotated. This procedure was repeated until all of the particles passed through the 50 mesh screen. The delumped material was then added to the slurry tank.

The remaining dry ingredients [#2, #4, #7, #8, #9, #12, #14, #15, #16, #19, #20, #21] were then added to the slurry tank. Only 1,016 lbs of coarse silica was added at this time, the design amount if all the ($Mg_2(PO_4)_3$) would be used.

The slurry mixture in the tank was then sampled (about 100 grams) and placed in a tarred crucible. The filled crucible was weighed and placed in an electric furnace. The furnace was heated to 200°F and maintained at that temperature until the slurry dried. The crucible was then removed from the furnace and weighed. The moisture content of the slurry was then calculated based on the difference in weight before and after drying. The amount of water that must be added to the slurry to achieve 70% water in the slurry was then calculated. The increase in the level of the slurry in the tank that would result in the addition of the water was calculated based on the tank dimensions, and a mark made at that level on the inside surface of the tank. Deionized water was then added to the slurry tank until that level was achieved.

After completion of the DS slurry preparation (except for the additional ($Mg_2(PO_4)_3$) on November 12, a 1 liter sample of the slurry was taken from the recirculation line by Horizon and sent to FDF for leachability analysis. Based on the leachability data, FDF decided not to add any additional $Mg_2(PO_4)_3$, but to replace the additional $Mg_2(PO_4)_3$ with coarse silica, bringing the total quantity of coarse silica in the slurry to that shown in Table 3-3. The additional silica was added on November 30, 1998, the day before the beginning of the POP test.

Immediately before the beginning of the POP test, additional samples of the slurry were taken from the recirculation line. The moisture content of the DS slurry was again measured by Vortec and found to be 70% (FDF independent analysis indicated a 71% moisture content).

On November 30, 1998, the dry glass additives were mixed in preparation for the POP test. The ingredients were split into 10 batches, one for each population, each having the quantities shown in Table 3-4, and placed in separate flexible intermediate bulk containers (supersacks). The quantity of additives was established for each population based on the processing of 2,000 lbs. of DSF per population with 90% DS and 10% glass additives. Each supersack was marked with a corresponding population number from 1 to 10.

3.2 72-HOUR TEST PREPARATIONS

Vortec prepared a Work Plan and submitted it to FDF for approval. The Vortec prepared Work Plan includes the Test Plan that clearly states the test objectives; describes the CMS™ technology; defines surrogate slurry formulation; provides the process measurement, sampling analysis, quality control, and testing procedures; and provides the sampling/analysis data management plans. In addition, the test plan gives general operation instructions to the test director and his staff.

3.2.1 Slurry Feeding and Injection Subsystem

To conduct the POP test, modification were required to Vortec Corporation's test facility to allow for the preparation and feeding of the 18,469 pounds of the Demonstration Slurry. Figure 3-1 is a photograph of the interior of this facility showing the reactor, melter and separator reservoir. A 2,000-gallon mixing tank was placed on the ground floor of the facility and was used to mix the full amount of demonstration slurry. However, the test plan called for breaking the feedstock (slurry plus glass additives) into 10 separate populations for ease of characterization over the test duration. Two 200-gallon tanks were installed on the third level and were used to mix the slurry and glass making additives prior to feeding the mixture into the melters. Figure 3-2 presents a photograph of the two 200-gallon slurry feed tanks. Note: (The term feedstock indicates that the surrogate, water, and glass additives have been combined in the correct proportions to produce a glass).

Table 3-3. Demonstration Surrogate Slurry Composition

		Weight	
Ingredient No.	**Ingredient**	**lb**	**kg**
1	Na_2HAsO_4	14.54	6.59
2	$BaSO_4$	417.51	189.3
3	Na_2CrO_4	13.82	6.27
4	Fe_2O_3	128.93	58.5
5	$Mg_3(PO_4)_2$	96.8	43.9
6	$NaNO_3$	52.58	23.8
7	NiO	21.94	9.95
8	PbO	289.26	131.2
9	$PbCO_3$	336.87	152.8
10	$PbSO_4$	135.41	61.4
11	Na_2SeO_3	7.75	3.51
12	Coarse SiO_2	1,061.57	460.8
13	Fine SiO_2	964.38	437.4
14	Fumed SiO_2	467.6	212.1
15	V_2O_5	4.60	2.09
16	ZnO	0.51	0.231
17	Tributyl Phosphate	46.92	21.28
18	Kerosene	46.92	21.28
19	Diatomaceous Earth	93.34	42.33
20	Feldspar	934.8	423.9
21	Bento Grout™	475.3	215.6
22	Deionized Water	12,585.0	5,831.0
Total		18,469.4	8,376.1

Table 3-4. Quantity of Glass Additives Prepared Per Population

Ingredient	Lbs per Supersack	Kg per Supersack
Li_2CO_3 (Lithium Carbonate)	55.0	24.94
Na_2CO_3 (Soda Ash)	55.0	24.94
$CaCO_3$ (Limestone)	90.0	40.82
Total	200.0	90.70

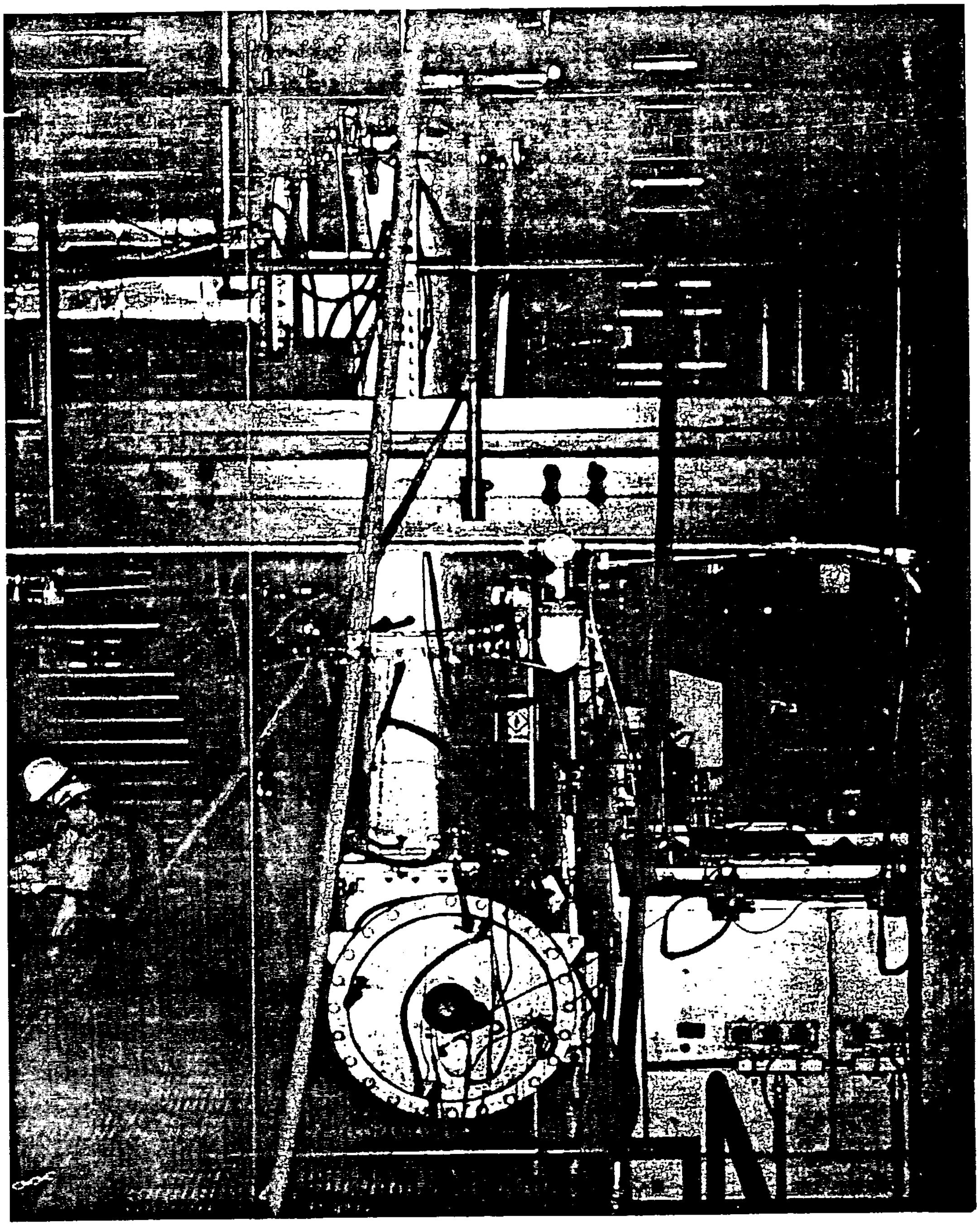

Figure 3-1. Interior View of the Vortec Test Facility

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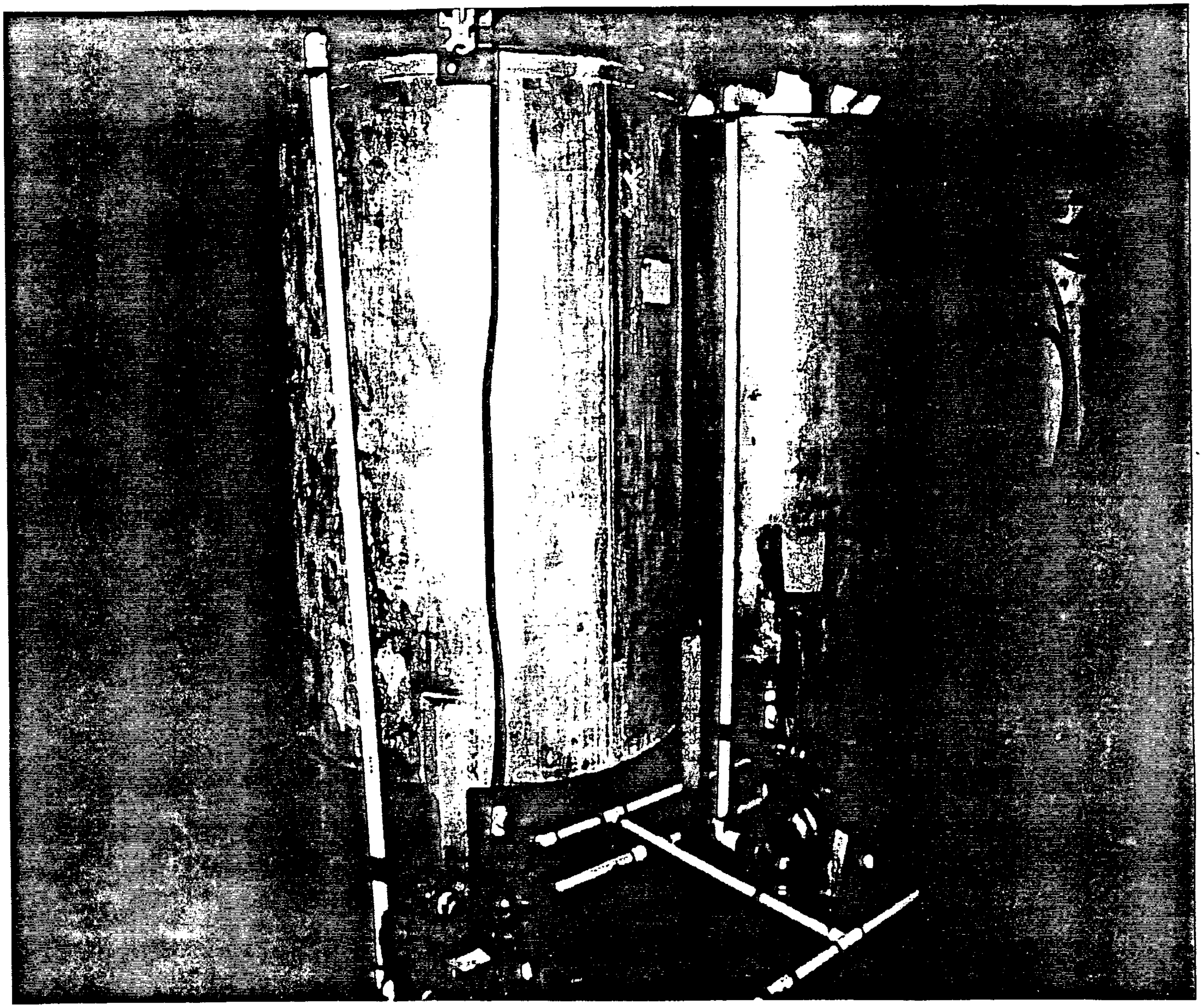

Figure 3-2. Slurry Feed Tanks

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3.3 DESCRIPTION OF THE U-PARC TEST FACILITY

Figure 3-3 is a block diagram of the Vortec CMS™ test facility at U-PARC in Harmarville, PA. The system has a maximum thermal input of about 5 MM Btu/hr constrained by the facility gas supply pressure. The system is capable of processing nominally 10-15 tons/day of dry material at 2,500°F (1,371°C), depending on the feedstock. Liquid additions to the feedstock will derate the system throughput as a function of the evaporation heating load, while operation at lower temperatures will reduce the solids heating load and allow increases in the processing rate.

The CMS™ consists of slurry feeding and injection subsystems; an indirect-fired air preheating subsystem; a reaction and melting subsystem, which includes the counter-rotating-vortex (CRV) preheater/reactor, cyclone glass melter (CM), and glass/gas separator-reservoir (S/R); an APC subsystem; a vitrified product handing subsystem; and an instrumentation and control subsystem. A flue gas instrumentation system, containing four Rosemount Analytical/Beckman analyzers, provides for on-line continuous measurement of CO, O_2, SO_2, and NO_X. In addition, the exhaust ductwork has ports to allow flue gas sampling and analysis in accordance with EPA Methods for particulate emissions, specific gases, and total hydrocarbons. The instrumentation and control system is PLC based and utilizes a PC for the graphical user interface. Data logging is provided for critical temperature, pressure, and flow measurements made in the course of a typical test run. The test system is installed in a High Bay Area, with plan dimensions of 40' x 100', and a height of 64 ft. This area includes a tower for support of test equipment, and a 5-ton bridge crane.

Summary descriptions of each test facility subsystem are provided in the following sub-sections.

3.3.1 Demonstration Surrogate Feeding and Injection Subsystem

DS slurry is prepared in the slurry mixing and storage tank that is equipped with an agitator and a circulation pump to keep the slurry solids in suspension. The circulation pump is also used to transfer slurry to two feed tanks. Each feed tank contains one tenth of the total slurry (one population) required for the test. Dry glass forming additives are added to the slurry in each feed tank to form a DS feedstock (DSF). While tank "A" is delivering DSF to the CMS™, tank "B" is filled and sampled. Each feed tank is equipped with an agitator and a circulation pump to keep the solids in suspension in the slurry. A metering pump delivers DSF to the injector from the feed tanks.

3.3.2 Reaction Air Subsytem

The reactor air subsystem consists of a forced draft blower and a separately, natural gas fired air heater. The reaction air leaves the forced draft fan and passes through the air heater where it is preheated to nominally 1,000°F (538°C). Stainless steel balance valves in the inlet piping adjust the air flow at the entrance to the CRV.

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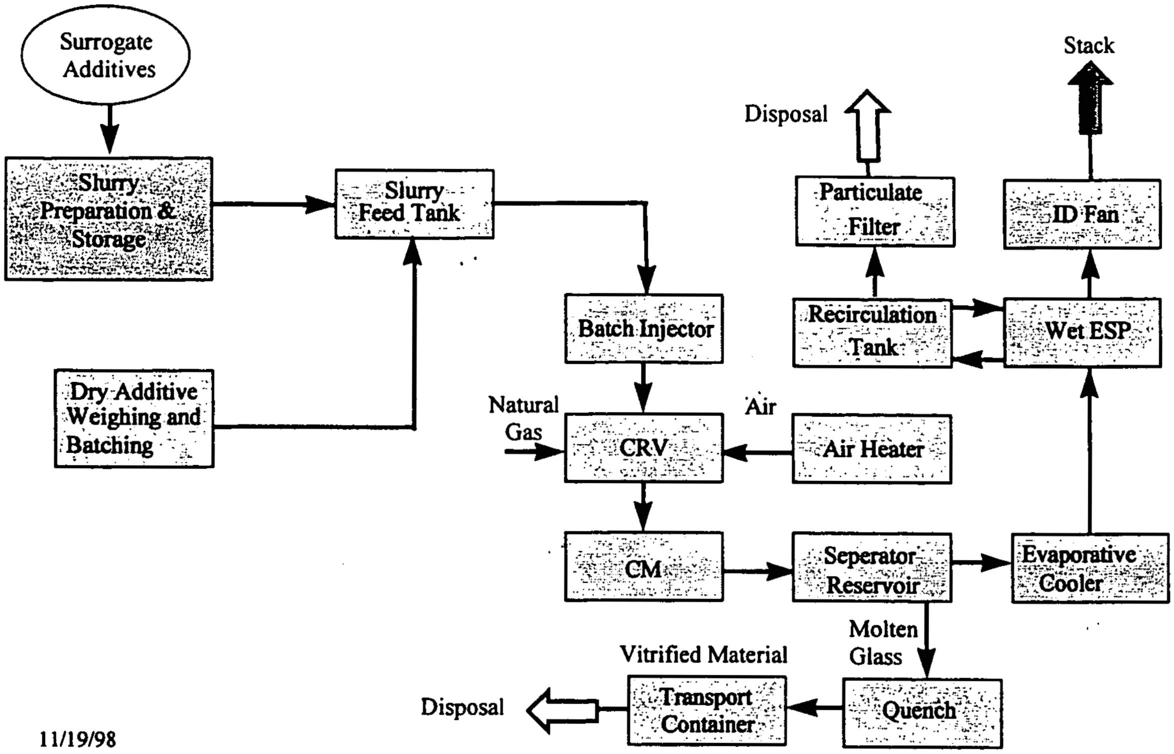

Figure 3-3. Top Level Block Diagram for the Vortec U-PARC Test Facility

3.3.3 Reactor and Melting Subsystem (CMS™)

The Vortec CMS™ consists of three major components: the CRV reactor, the CM, and the S/R. The DSF is axially injected and atomized at the top of the CRV reactor. Natural gas and pre-heated reactor air are introduced co-currently with the feed injector and tangentially into the reactor through two inlet arms in such a manner as to create two counter-rotating flow streams. As a result of the intense counter-rotating vortex mixing, it is possible to achieve reaction stability in the presence of large quantities of inert particulate matter. Both convection and radiation heat transfer mechanisms contribute to the rapid evaporation of the liquid phase and subsequent heating of the solid phase within the CRV reactor. The heated feedstock flows from the CRV reactor into the CM where glass reactions are completed and the product is separated from the gas stream. The S/R has a floor tap to deliver glass from the CM (alternatively, a bath of molten glass can be maintained) and routes the separated flue gas to the flue gas handling system. Descriptions of these items follow.

3.3.4 CRV Reactor Assembly

The preheated reaction air and natural gas enter the CRV reactor via the lid and the inlet arms. Initial heating occurs in a pre-reactor stage between the lid and the inlet arms. At the inlet arm stage, the high inlet velocities provide a well-stirred upper section for flame stability and effective oxidation of organics and batch heating. The CRV reactor is a refractory lined, carbon steel, water cooled vessel. Water cooling maintains the metal surfaces of the vessel below 125°F. The vessel includes interconnecting tubing between water jacket segments and fittings for view ports, thermocouples, pilot burners, and flame safety devices.

3.3.5 Cyclone Melter Assembly

Hot gases and preheated solid materials exit the CRV reactor and enter the CM where the glass melting is completed. The CM is a horizontal cylinder with a vertical tangential entrance at one end and a horizontal tangential exit at the floor of the melter at the other end. Gas dynamics within the melter separate the glass from the gas products. The glass flows through the CM in a thin layer, principally along the floor of the horizontal cylinder. The gas and the glass exit together through the tangential exit, with the glass remaining on the floor and continuing on into the S/R. The melter is a refractory lined, carbon steel, water-cooled vessel. Water-cooling maintains the metal surfaces of the vessel below 125°F (52°C).

3.3.6 Separator/Reservoir

The S/R is a refractory lined chamber that completes the separation of the glass from the reaction products and provides the ability to maintain a pool of glass if required for dissolution or homogeneity. The glass exits the cyclone melter into a channel in the S/R. A weir was constructed at the end of the channel for the proof of principle test to build up a pool of glass, thus providing for a glass residence time of about an hour. Glass flowing over the weir forms a cylindrical stream and drops through a tap hole in the floor of the channel. The hot gases are directed from the separation chamber to the evaporative cooler interfacing ductwork.

3.3.7 Flue Gas Treatment System

The flue gas is conditioned by an evaporative cooler to reduce the temperature to nominally 450°F (232°C) to allow for flue gas sampling and ease of handling to the WESP. The flue gas from the S/R is directed to the evaporative cooler via a refractory lined steel duct. In the evaporative cooler, air-atomized water is sprayed into the flue gas at the top of the cooler. The evaporation of the water cools the flue gas to the design temperature. The flue gas discharges from the bottom of the evaporative cooler into stainless steel ductwork leading to the WESP.

The primary stage of the WESP is a rod deck venturi scrubber that removes large particulate and saturates the flue gas prior to entering the WESP. Final particulate removal occurs in the WESP. The WESP water is recirculated through storage tanks where make-up water is added and the pH is adjusted in the range of 5 to 8. Emission testing is performed to characterize the uncontrolled emissions upstream of the WESP in support of the design of an appropriate commercial flue gas handling system. At the conclusion of a test, the WESP water is run through a filter press to remove the solids. The solids and the liquid are disposed of as required.

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3.4 Test Procedure

Vortec operates the test facility in an automatic data logging mode with critical parameters displayed on the control room monitor. The control room contains the remote controls for the following critical parameters:

1. Fuel and air flow to the CRV reactor (inlet arms).
2. Gas temperatures at the CM exit and S/R exit.
3. Gas temperatures at the CRV reactor lid.
4. Slurry/additive feed pump speed.
5. Separator/Reservoir pressure.

The system is instrumented with a distributed control system for automatic operation. However, when new materials and procedures are being tested, Vortec's operating experience indicates that continuous manual monitoring and adjustment of the system is required. At 30 minutes intervals the operator:

1. Adjusts the fuel and airflow to the CRV and the S/R to maintain the design gas temperatures at the CRV lid, cyclone melter,and S/R.
2. Calculate the average slurry/additive batch feed rate and adjust the slurry/additive pump speed if necessary to maintain the design feed rate.
3. The Test Director monitors the flow of glass in the CM to determine if the viscosity appears to be satisfactory (subjective judgement on the part of the Test Director).

The Test Director and the control room operator are in continuous communication during the test, with the operator required to remain in the control room.

4.0 SAMPLING AND ANALYSIS

4.1 Sampling Procedures

In addition to the system performance data that is provided by the mass and energy calculations, FDF asked for glass and feedstock samples. These glass and feedstock samples were collected as described in the Test Report (see Appendix B) and were analyzed by Corning's CELS Laboratory.

4.1.1 Sampling Points and Data Requirements

The CMS™ process is to be evaluated based on the conversion of the silo residue into a glass that is chemically durable with respect to the leachability of contaminants and the other criteria listed in Table 3-2. A number of process variables were measured and samples of input and output streams were obtained for analysis. To limit the sampling and measurement requirements to a reasonable level, a comprehensive sampling matrix was designed in accordance with the Test Plan. The product glass sampling frequency is outlined in Table 4-1. FDF designated that sampling for record should occur during the processing of Populations 2, 5, and 9.

Figure 4-1 is a process flow diagram for the U-PARC test facility that includes the sampling point numerical designators. The sampling locations are the process inlet and exit points for the flow streams that require chemical analysis. The analysis of the feedstock is the starting point for verification of composition and quantification of contaminants. The partitioning of the elements of interest among the various outlet streams is determined through chemical analysis of the outlet stream samples and the mass flows measured during the test-sampling period.

In each of the following sections, a description is given of the method used in obtaining the various required samples. Horizon and Vortec were fully prepared for sampling before initiation of the 72-hour test. Preparation for sampling included the acquisition of all necessary sampling equipment and site-specific information. Horizon assured that the sampling was accomplished as required by the standard EPA protocols defined in EPA SW 846 or their equivalent.

4.1.2 Demonstration Surrogate (DS)

The DS slurry was prepared in a nominal 2,000 gallon capacity mix tank approximately 3 weeks prior to initiation of the 72-hour test. During operations, quantities sufficient for each sample population (1/10 of total slurry) were pumped into one of two 200 gallon feed tanks at the beginning of the previous population period. A slurry sample was obtained from the slurry population as it entered the 200 gallon tank. A one-third liter sample was taken at the start of tank filling, a one-third liter sample at the filling mid-point, and a one-third liter sample at the end of the filling period. These samples were composited into a single 1-liter sample. The sampling point is designated S1 in Figure 4-1.

Table 4-1. Glass Sampling Schedule

Population	No. Samples	Sample Size	Analysis	Destination	Total Samples per Population
Glass Patties					
All Populations	1	1 patty	Archive	Vortec	6
Frit					
All Populations	1	1 liter	Archive	FDF	1
	1	3 liters	Archive Final	FDF	1
	1	1 liter	Archive	Vortec	1

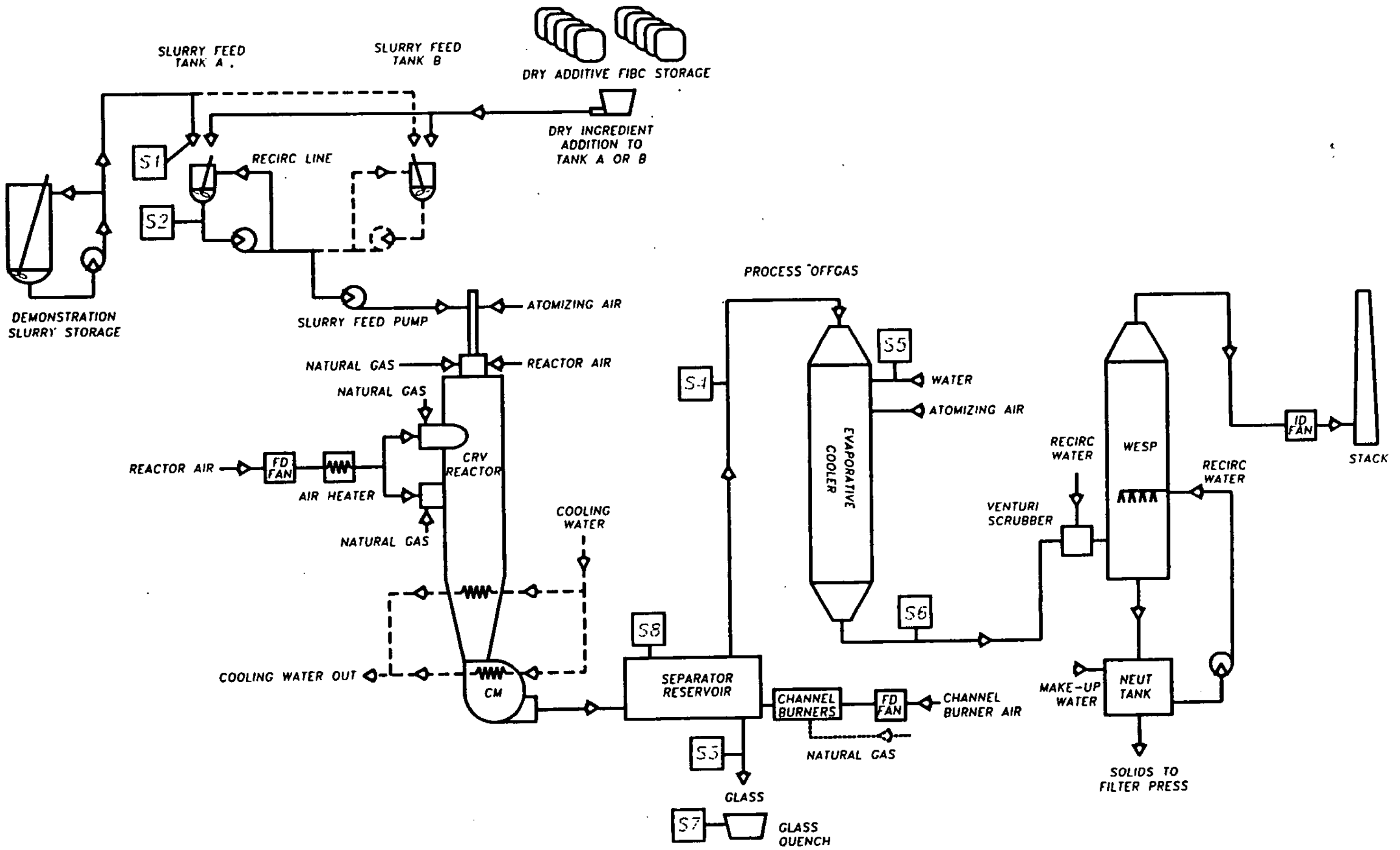

Figure 4-1. Process Flow Diagram for Proof of Principle Test at U-PARC

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4.1.3 Demonstration Surrogate Feedstock (DSF)

Dry glass forming additives were mixed with the Demonstration Slurry in each 200-gallon feed tank after the Demonstration Slurry had been transferred to the 200 gallon feed tank and sampled. The DSF was blended in the feed tank via the agitator and recirculated for a period of about 6 hours. A sample of the DSF was then taken at the end of the 6-hour period. The DSF sample was taken from the recirculation line (sample designation S2).

4.1.4 Glass Patty and Frit Samples

There are no formal ASTM procedures for sampling the treated surrogate (glass), so the following methodology was utilized to standardize the process. Vortec personnel obtained the glass patty samples from the stream of molten glass at sampling site S3. Each patty was formed by using a steel ladle to catch the glass stream for one minute. The ladle was cooled in water by immersion and rinsed with distilled water between samples to reduce the chance of contamination. The samples were placed in stainless steel containers to air cool and allowed to fracture. After drying, Horizon personnel placed the samples in airtight containers and labeled the containers as per the chain of custody format. Six glass patty samples were taken for each of the ten populations being processed, one every hour beginning 1 hour after the start of the population period.

Glass frit samples were collected once per population period, by Vortec personnel placing a slotted scoop in the glass quench water below the molten glass stream. After glass frit had been collected, the scoop was removed, the water drained, and the sample placed in a perforated container and allowed to dry. A total of five liters of frit were sampled in this manner for each population period. The samples were then placed in containers by Horizon personnel who labeled the containers in accordance with the chain of custody procedures.

4.1.5 Evaporative Cooler Water

One composite evaporative cooler water sample was obtained by Horizon personnel from the municipal water input to the cooler system at Sampling Site S5. The purpose of collecting the sample was to determine if there is any metal contamination in the water that would increase the concentrations in the flue gas particulate. The water sample was analyzed for Si, Al, Ca, Mg, Na, K, Fe, Li, Ba, Zn, Ni, Pb, Cr, V, P, As, Se, and total solids, and was essentially at drinking water standards.

4.1.6 Flue Gas Particulate

The quantity of flue gas particulate was sampled by EPA Method 5 as described in 40 CFR, Part 60, by Comprehensive Safety Compliance, Inc. (CSC) at sampling site S6, Figure 4-1. A bulk flue gas particulate sample was also collected for chemical analysis.

CSC was responsible for obtaining this material in accordance with the protocols. They then transferred the samples to Horizon personnel who placed them in containers labeled in accordance with the chain of custody procedures. The particulate samples that correspond to the three random glass-sampling events were sent out for chemical analysis. (See data package of deliverables for the analyses conducted and the results on the bulk particulate). EPA Method 6 was performed to measure the quantity of SO_2 in the off-gas.

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4.1.7 Flue Gas Composition

A Vortec managed flue gas instrumentation system, containing four Rosemount Analytical/Beckman analyzers, provided for on-line continuous measurement of CO, O_2, SO_2, and NOx at sampling site S4. CSC also sampled the flue gas for SO_2 at sample site S6.

4.2 ANALYTICAL RESULTS

Table 4-2 lists the influent and effluent streams tested from the 72-hour test. It describes which streams were tested for total metals and which were tested for leachable metals. The leaching tests were conducted on the 8-RCRA metals, as well as Sb, Ni, and Zn. The leaching results were evaluated for their compliance with current TCLP regulations.

Analysis of the slurry, dry feedstock, evaporative cooler water, particulate and glass was completed by Corning's Laboratory.

Table 4-2. Laboratory Analysis of Pilot Scale Test Results

Stream	Metals Concentration	Leachability
Feedstock Slurry	yes	---
Dry Feedstock	yes	---
Glass	yes	TCLP/UTS
Evaporative Cooler Water	yes	---
Flue Gas Particulate	yes	---

5.0 RESULTS AND DATA ANALYSIS

5.1. 72-HOUR TEST

Section 5.1 will summarize the data developed during the 72-hour test. This section will also comment on the key issues of concern established by the 72-hour test. Section 5.2 discusses the glass development procedures, and presents all data generated in the laboratory studies.

5.1.1 TCLP Results

Table 5-1 presents the TCLP results for populations 2, 5, and 9. The FDF specification required the glass to leach at no more than 50% of the rates in 40 CFR 261.24. Lead, which is the element of concern, leached at an average rate of 0.61PPM (maximum rate of 0.93), considerably below the allowable leaching rate of 2.5 PPM. The UTS rates are also included in the table for comparison.

Table 5-1. Vitrified Product TCLP Results from POP Test (mg/L)

				TCLP	UTS
	Pop. 2	**Pop. 5**	**Pop. 9**	**40 CFR 261.24**	**Promulgated**
Arsenic	<0.0870	<0.087	<0.087	5.0	5.0
Barium	0.22	0.29	0.89	100.0	21.0
Cadmium	<0.024	<0.024	<0.024	1.0	0.11
Chromium	<0.055	<0.054	<0.054	5.0	0.60
Lead	0.46	0.42	0.93	5.0	0.75
Mercury	<0.00075	<0.00075	<0.00075	0.2	0.025
Selenium	<0.20	<0.20	<0.20	1.0	5.7
Silver	<0.023	<0.022	<0.022	5.0	0.14
Antimony	<0.10	<0.10	<0.10	NA	1.15
Nickel	<0.026	0.027	0.053	NA	11.0
Zinc	<0.023	<0.023	<0.023	NA	4.3

5.1.2 Explanation of the 0.93 mg/l Lead Leachate Concentration for Population 9.

The 0.93 mg/l lead TCLP leachate concentration for the glass produced for population 9 is greater than that obtained for the glasses produced during populations 2 and 5, (0.46 and 0.49 mg/l, respectively). According to the Vortec glass model (see section 5.2.3) the lead leachate concentration is a function of the amount of PbO in the glass and the glass composition. The glass composition controls the glass structure, which determines how tightly the lead ions are bound to the glass. The lead concentration for the population 9 glass is similar to that obtained for the earlier populations, but the SiO_2 concentration is lower (47.7 wt. % compared to 56.9 and 57.4 wt.%, see Table 5-2) and the alkali and alkaline earth metal oxide fluxes are higher.

According to the Vortec glass model used to relate the glass compositions to the glass durability, the lead leachate level should, as observed, increase. It is interesting to note that even with a 20%-30% variation in SO_2 in the feedstock, the CMS™ was still capable of making a glass that passed the 50% TCLP criteria. This is an indication of a robust process, see Section 7.4 for additional discussions.

5.1.3 Mass and Energy Balance

Mass and energy balance evaluations for each of the populations 2, 5, and 9 were prepared using the analytical data generated by CELS and CSC from the samples of the slurry, glass, and flue gas. The data presented in Table 5-2 compare two results for selected groupings of the elements and compounds contained in the demonstration surrogate. The column labeled "Glass Calculated" presents the composition of the glass based on the measured concentrations and flow rates of a compound in the input slurry and the exiting flue gas. The column labeled "Glass as Analyzed" is the corresponding composition developed by CELS directly from the glass samples taken from populations 2, 5, and 9. These data, for each of the compounds of concern, are in good agreement, except for aluminum oxide.

Table 5-2. 72-Hour Proof of Principle Test Mass and Energy Balance Data

Constituent	DSF (Lbs/Hr) Pop #2	DSF Pop #5	DSF Pop #9	DSF Average	Partioning to Flue Gas (Lbs/Hr) Pop #2	Flue Gas Pop #5	Flue Gas Pop #9	Flue Gas Average
Fluxes - Alkali	13.24	10.34	10.66	11.41	0.64	0.65	0.89	0.73
Fluxes - Alkaline	10.65	7.49	12.86	10.34	0.65	0.56	0.73	0.65
Glassformers								
Al2O3	3.73	2.59	3.70	3.34	0.15	0.10	0.14	0.13
Al2O3 (from refractory erosion)								
SiO2	51.73	52.64	35.32	46.56	1.24	1.06	1.44	1.25
Special Interest								
PbO	9.48	7.95	10.73	9.39	3.57	4.68	5.44	4.56
SO3 - Sulfate Solid	4.20	2.93	4.19	3.77	1.39	1.72	1.96	1.69
P2O5 - Phosphate	1.85	1.45	1.29	1.53	-	-	-	-
Other	19.06	15.85	21.56	18.83	0.16	0.12	0.19	0.16
Total Solids	113.95	101.23	100.33	105.17	7.80	8.90	10.80	9.17
H2O (Liquid)	194.02	172.36	170.83	179.07				-
SO3 (gas)					1.88	0.75	0.50	1.04
Others (CO2, NOx, etc.) (gas)					16.43	13.93	18.68	16.35
H2O (gas)					194.02	172.36	170.83	179.07
Total Non-solids	194.02	172.36	170.83	179.07	212.34	187.04	190.01	196.46
Total All	307.98	273.58	271.15	284.24	220.14	195.94	200.81	205.63

Constituent	Glass, Calculated (Lbs/Hr) Pop #2	Pop #5	Pop #9	Average	Glass, Calculated (%) Pop #2	Pop #5	Pop #9	Average	Glass, As Analyzed (%) Pop #2	Pop #5	Pop #9	Average
Fluxes - Alkali	12.60	9.68	9.77	10.69	13.71%	11.85%	12.88%	12.81%	9.89%	10.99%	13.43%	11.44%
Fluxes - Alkaline	10.00	6.93	12.13	9.69	10.88%	8.48%	15.99%	11.78%	13.38%	13.37%	16.17%	14.31%
Glassformers												
Al2O3	3.58	2.49	3.56	3.21	3.89%	3.04%	4.70%	3.88%	8.35%	8.00%	11.98%	9.44%
Al2O3 (from refractory erosion)	4.10	4.05	5.53	4.56	4.46%	4.96%	7.28%	5.57%		*Included in Al2O3 above*		
SiO2	50.49	51.58	33.88	45.32	54.92%	63.14%	44.65%	54.24%	56.91%	57.44%	47.68%	54.01%
Special Interest												
PbO	5.91	3.26	5.29	4.82	6.43%	4.00%	6.98%	5.80%	5.91%	5.17%	5.29%	5.46%
SO3 - Sulfate Solid	0.94	0.45	1.73	1.04	1.02%	0.55%	2.28%	1.28%	0.40%	0.25%	0.17%	0.27%
P2O5 - Phosphate	1.85	1.45	1.29	1.53	2.01%	1.77%	1.71%	1.83%	1.23%	1.25%	1.54%	1.34%
Other	2.47	1.80	2.68	2.32	2.69%	2.20%	3.54%	2.81%	3.93%	3.53%	3.74%	3.73%
Total Solids	91.94	81.69	75.87	83.17	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Input Streams (Lbs/Hr)

Constituent	Pop #2	Pop #5	Pop #9	Average
DS Dry Basis	83.15	73.87	73.21	76.74
Additives	30.80	27.36	27.12	28.42
Water	194.02	172.36	170.83	179.07
Total DSF	307.98	273.58	271.15	284.24

Output Streams (Lbs/Hr)

Constituent	*Pop #2*	Pop #5	Pop #9	Average
Glass	91.94	81.69	75.87	83.17
Particulate Carryover	7.80	8.90	10.80	9.17
Off-Gas	212.34	187.04	190.01	196.46
Refractory	(4.10)	(4.05)	(5.53)	(4.56)
Total	307.98	273.58	271.15	284.24

000031

The Al_2O_3 is a constituent of the fused cast AZS refractory that is still being used in the pilot facility. Typically, a small amount of this material is found in the glass. Certain sections of the separator reservoir in the U-PARC test facility are lined with this AZS refractory. This material has superior thermal shock resistance and is the material of choice at selected locations since the test facility cycles from cold stand-by to operating temperatures many times during the year. By contrast, the full-scale system would either be held at operating temperature or, if needed, held at hot stand-by conditions. A high alumna refractory would most likely be used in the full-scale system with its superior erosion characteristics, thus reducing the amount of refractory wear. Refractory erosions information from the POP test should not be used to predict wear rates in any full-scale design. Estimates of the wear rate would be developed with additional long term testing at U-PARC (probably much longer than 72 hours) using a K-65 residue simulant in the operating temperature range.

Complete mass and energy balance data are presented in the Test Report, Appendix B. The test data and logs were transmitted, as directed by FDF, in a separate deliverable package (Deliverable Number 40720-2241-C4-001). System thermodynamic performance is summarized for convenience in Figures 5-1, 5-2 and 5-3.

5.1.4 Lead Capture and Recycle

The somewhat lower TCLP lead leachate concentration obtained from the glasses prepared during the 72-hour demonstration test was partly a result of the decreased PbO concentration in the glass due to volatilization. No attempt was made during the 72-hour test to recycle lead into the glass melter. This technique was demonstrated in an EPA SBIR program and described in an EPA report in December 1992, see reference in Section 1.5.

The glass formulation for the demonstration test was designed to pass the TCLP leaching requirement for lead when all of the lead compounds in the Demonstration Surrogate reports to the glass. In fact, as seen in Table 5-6a, the glass made from the DS in the laboratory contained 11 wt % lead compounds, and this glass did pass the TCLP test. The recycling of the lead-compounds into the glass will not increase the PbO concentration in the glass to a level greater than that if all of the lead went directly into the glass.

5.1.5 Sulfur Removal

It is expected that lead sulfate will be the primary particulate collected by the bag filter. As previously indicated, it is intended to recycle the particulate into the melter. Once the glass becomes saturated with SO_3, at about 0.5%, all the remaining sulfur will stay in the gas phase as SO_2. In the gas phase some of the sulfur will combine with the volatilized lead to form lead sulfate when the off-gas is quenched in the evaporative cooler. However, the sulfur remaining in this SO_2 stream will be equal to the incoming sulfur minus the amount leaving with the glass. The SO_2 gas passing through the bag filter will be removed in the SO_2 removal system.

FDF 72 HOUR TEST POPULATION #2 12/1/98

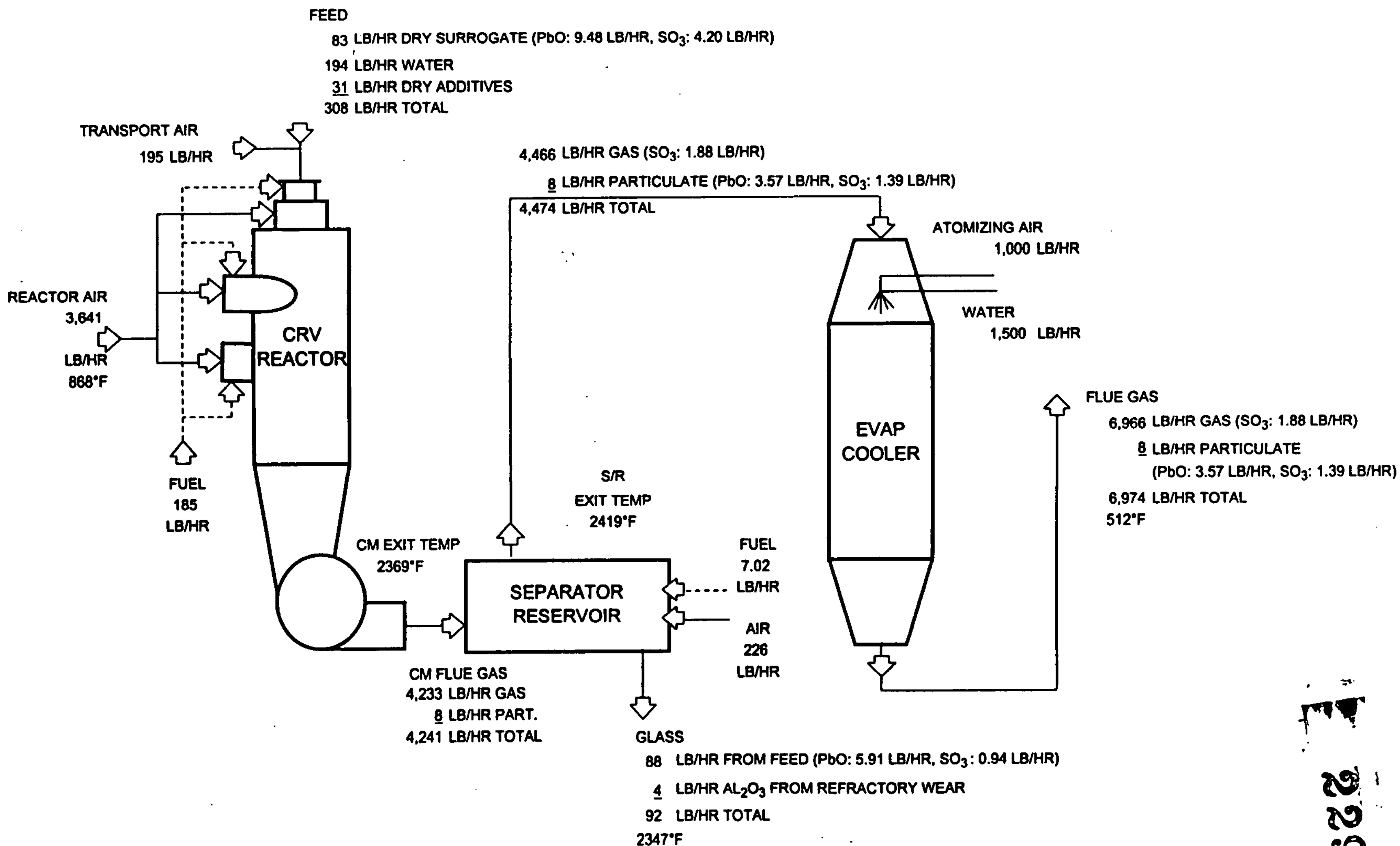

Figure 5-1. Proof of Principle Test Process Flow Data for Population #2

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E 2295

FDF 72 HOUR TEST POPULATION #5 12/2/98

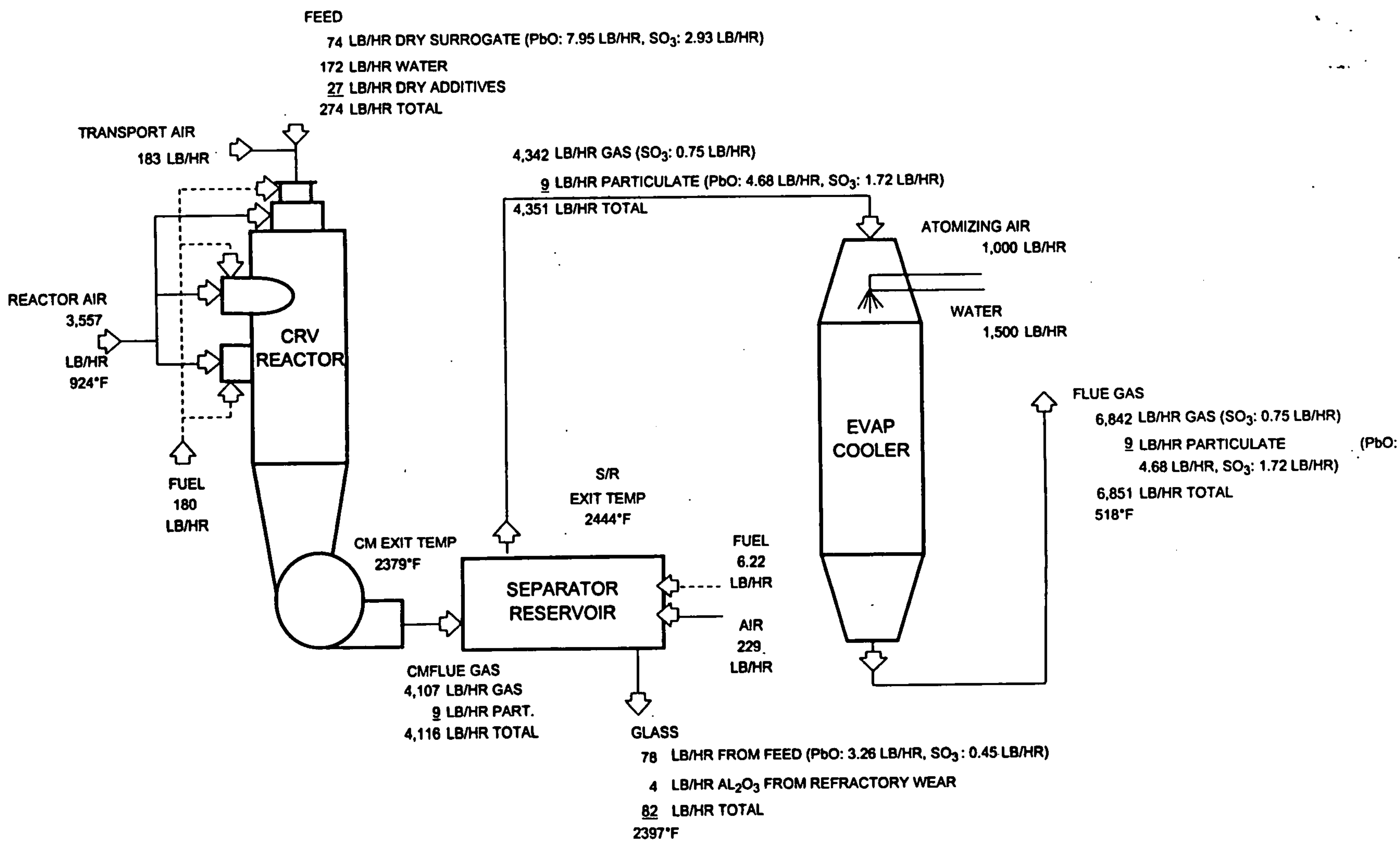

Figure 5-2. Proof of Principle Test Process Flow Data for Population #5

000034

FDF 72 HOUR TEST POPULATION #9 12/4/98

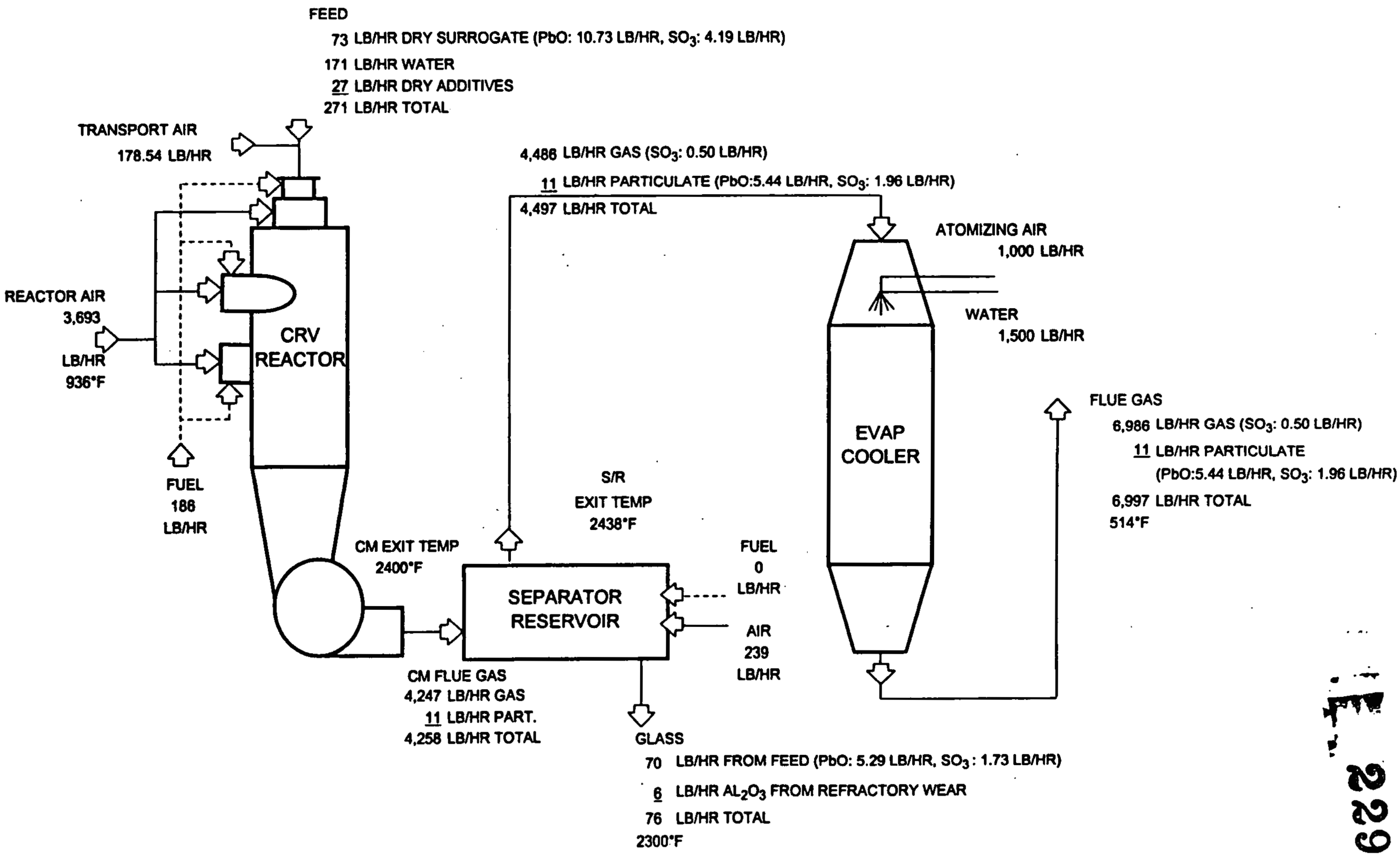

Figure 5-3. Proof of Principle Test Process Flow Data for Population #9

000035

229 5

5.1.6 Waste Loading

Waste loading refers to the quantity of initial waste present in the final treated waste form. In the case of vitrification, this is largely dictated by the glass chemistry, which is designed to give the desired durability and melt temperature properties. The silo residues have a large fraction of usable glass making ingredients that result in favorable waste loading values.

During the POP test, the vitrified product had a waste loading of between 85% and 90%. If all of the captured particulate were recycled, the measured waste load would be identical with the laboratory values to be reported in Table 5-6a. (Table 5-6a/b, provided in Section 5.2, provides waste loading data on all of the laboratory glasses).

5.1.7 Processability

The overall controllability of the CMS™ technology is indicated by the single unplanned event that occurred during the 72-hour test. On December 2, approximately 27 hours after the start of the test, a fuse in the slurry feed pump motor control failed, interrupting power to the pump. A replacement fuse was installed , and total interruption in feed to the CMS™ was limited to 7 minutes. During this time, the natural gas and airflow rates to the CMS™ were adjusted in response to changes in system temperature. The operator, noting the temperature melter rise, decreased natural gas input to the system to control the temperature to the design level. This was accomplished in less than 5 minutes. Slightly later, after the pump was restarted, the system temperature began to decrease in response to reintroduction of feed into the CMS™. The operator again responded by increasing the natural gas flow to recover temperature and followed with adjustments to the natural gas flow to stabilize the temperature within the design operating range. From the time the feed was restarted until the system parameters were re-stabilized was about 20 minutes. A plot of temperature and natural gas flow rate versus time is included in the Test Report, Appendix B, along with a detailed discussion of the event.

The preceding event is indicative of the ease of process control enjoyed by the CMS™. High throughput, low inventories of feedstock in the melter, and high levels of turbulent mixing are all features that lend themselves to responsive process control. This responsiveness also allows the CMS™ to follow variations in chemical composition of the input stream on an almost real time basis. During the 72-hour test, the reservoir contained no more than 200 pounds of molten glass at any given time. If a shutdown of the system had been necessary, simply stopping the feed-stock flow to the melter would result in the melter being drained in approximately 1 hour. Start-up from a hot standby condition would be equally as rapid.

5.1.8 Refractory Considerations

The data presented in Table 5-2 indicates good agreement between the oxide concentrations as determined from the mass balance calculation as compared to oxide concentrations reported in the glass analysis. The consistently larger value for Al_2O_3 in the glass by about 5% is attributed to the CMS™ refractory system and the installation of new refractories in some portions of the reservoir.

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The refractory used during the POP test in the Vortec Test Facility was largely AZS (alumina/zirconia/silica) material. This selection is based on favorable thermal shock properties as well as being a good general service refractory for a variety of glass compositions. The POP test proposal did not include any attempt to optimize the refractory selection or re-line the Vortec CMS™ with a more corrosion compatible refractory for the FDF silo glass. The CRV reactor and CM components have a proprietary wall construction, in which wear is minimized. The S/R, however, uses conventional glass tank construction techniques. The S/R portion of the system was rebuilt with new AZS materials for the POP test to create a pool with one hour of residence time and an overflow weir for discharge. A greater percentage of refractory wear occurred because refractory in this component was new.

For the full-scale unit, refractory selection will be part of a detailed design exercise that includes a determination of the best candidates from a chemical compatibility and mechanical properties standpoint, and, ultimately, dynamic refractory finger testing in the laboratory will be required.

5.1.9 Proof of Principle Test Meets Scale-up Criteria

The preliminary design for the feed preparation system, was changed to receive the tank residue from the TTA and dry it before it was transported to the CMS™ for vitrification. This change allowed the vaporization of the slurry's water at a much lower temperature, saving fuel and reducing the flue gas flow rate. An additional significant benefit from this system configuration change is the reduction in size of the CMS™ needed to process the 6,780 m^3 of silo residue in 36 months. With the system designed to process a dry feed into the reactor, the scale of the CMS™ full-scale system will be similar to the 15 TPD system at U-PARC. Thus, scale–up is not a factor of concern since the technology demonstration was run in a system that was essentially full-scale.

Vortec's commercial CMS™ at Ormet Primary Aluminum Corporation is a factor of four scale-up from the pilot-scale CMS™. Therefore, if it is desirable to design a larger CMS™ for more rapid remediation of the silo waste, Vortec has the experience to do this.

5.1.10 Bulking Factor

Bulking factors are reported in Table 5-6a, b for the glasses developed during the program.

5.1.11 Video Logs

As required by FDF the 72-hour test was video taped. Three cameras were continuously recording during the test as follows.

1. Activities in the control room.
2. Glass stream leaving the tap hole.
3. Slurry feed activities.

The log of videotapes provided to FDF is presented in the Test Report, Appendix B.

5.2 SURROGATE AND GLASS DEVELOPMENT PROCEDURE AND TEST RESULTS

The glass formulation process used by Vortec during the POP program is discussed in this section.

5.2.1 Surrogate Preparation and Characterization (Laboratory)

For the S1 and S2 surrogates, the materials were received already mixed from FDF. The DS surrogate was prepared by Vortec from bulk materials purchased for the 72-hour test.

The procedure for mixing the 70% solids surrogate materials from the raw materials was initiated by measuring all of the dry ingredients into a container, except for the fumed silica, and blending them to form a homogenous mixture. This mixture was then passed through a 40 mesh (425 micron) screen to ensure that all of the agglomerates were smaller than the largest coarse silica particles. Particles that remained on the screen, soft agglomerates, and water-soluble ingredients were crushed with a mortar and pestle so that they would pass through the screen. The fumed silica was then weighed out and placed in a container with the other ingredients and blended by shaking. Next, the organic ingredients were measured and slowly added to the dry ingredients. Finally, the amount of water required to achieve 70% solids in the surrogate was added. The mixture was blended until it appeared was uniform.

5.2.2 Preparation of Glasses (Laboratory)

Vitrifying the surrogates in the laboratory consisted of first preparing a slurry from the surrogate material, adding the glass forming ingredients, drying the glass batch, and melting the glass batch to form the final vitrified product. A 30% solids slurry was prepared with a final slurry composition of 70% water, 2.4% bentonite and 27.6% dry surrogate ingredients. The surrogate was prepared by first measuring out the water required and placing it in a container with zirconia milling media. The bentonite was then added to the water and dispersed by shaking. Then the surrogate (with 30% water) was added to the container and the container turned on rollers for approximately 1 hour to break up the agglomerates in the mixture. The glass additives were then added to the slurry and the slurry mixed for an additional hour. The resulting slurry was then poured into pans and placed in an oven at approximately 120°C (250°F) to dry. The resulting dry material was then crushed to less than 20 mesh for melting.

The glasses prepared in the laboratory were melted in an electric box furnace in porcelain crucibles. The crucibles were initially filled with batch and the crucibles heated to the desire melting temperature. Additions of glass batch were made to the melt to increase the volume of melted glass in the crucible. If a liquid sulfate phase appeared during the melt process, it was removed by pouring it from the crucible. After the crucible was filled with molten glass and there were no signs of a sulfate phase, the crucible was held at the melt temperature for 1 hour to allow the glass to homogenize. The crucible was then removed from the furnace and the molten glass poured into water to produce a glass cullet. The resulting glass cullet was dried and placed in labeled containers.

5.2.3 Vortec's Glass Model (Prediction of Lead Leach rate)

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For the vitrification of the FDF silo residue in the Vortec Corporation CMS™ , the glass product durability and the glass melt temperature are the properties of greatest concern. Based on the RFP, the durability of the glasses prepared were required to meet either one-half the present TCLP limits or the proposed UTS limits. Additionally, the maximum glass temperature of 1,300°C (2,372°F) was set by Vortec to minimize the volatilization of lead compounds during the vitrification process. An attempt was made to maximize waste loading to minimize the amount of glass requiring disposal. To aid in selecting the glass compositions for the different surrogates and durability criteria, a model was generated for the glass durability and composition limits as a function of the desired melt temperature.

To estimate the lead leachate concentration from a glass, a second model was generated relating the glass composition to the lead leachate level. This model was specifically designed to predict the lead leachate concentration in a TCLP test. In the model, the leachate concentration was assumed to be a function of the amount of lead in the glass and the glass structure. The model treated these two components individually.

The lead leachate concentration was assumed to be proportional to the amount of lead present in the glass. Therefore, to separate the effects of PbO concentration on the lead leachate concentration, the lead leachate concentrations were normalized to the molar PbO glass concentrations. This normalization resulted in establishing a lead ratio between the leachate and the glass. The lead ratio for a glass is assumed to be a function of the glass composition.

For the structure portion of the model, the assumption was made that the lead ratio was proportional to a glass structure factor. The glass structure factor is also related to the glass composition. In general, the oxides in the glass were divided into four groups, SiO_2, alkali metal, alkaline earth metal and 2+metal (PbO and ZnO) oxides, and Al_2O_3 and Fe_2O_3. The concentrations of the oxides in a group were summed together and treated as a single concentration. A structure factor, and thus the lead ratio, could be calculated from the concentrations for the individual groups. The factor relating the structure factor to the lead ratio was determined from experimental data collected in the laboratory and data presented in the literature.*

Using the model and the glass composition, a TCLP lead leachate concentration can be calculated. For the data sets collected, the lead leachate concentration was calculated using the model and the results presented in Figure 5-5. The outlying data point corresponding to the point in the earlier calculations is circled and represents the "First Try" at a suitable composition. The data present show a 1 to 1 correlation that indicates the effectiveness of the model.

*Reference: R.A Merrill and D.S. Janke, "Results of Vitrifying Fernald OU-4 Waste" Ceramic Transactions, Vol. 39, Environmental and Waste Management Issues in the Ceramic Industry, edited by George Mellinger, pg. 33-44, (1994).

Fifteen glass composition and lead leachate concentration data points were collected during this investigation and used to determine the factors in the model. A plot of the calculated lead ratios versus the measured lead ratios is shown in Figure 5-4. The data in this figure show a strong 1 to 1 correlation indicating the effectiveness of the model for predicting the lead ratio for a given glass. The initial outlying point is circled and represents the "First Try" at a suitable composition. Additionally, the maximum and minimum limits are shown for additional data points based on a 3σ variation from a linear fit to the data.

The lead ratios for the final glasses prepared for the FDF investigations are also shown in Figure 5-4. The S1-U and S2-U glasses do not fit the model well. The initial examination of these glasses showed that they were not homogeneous, so the exact composition of the phase present was not known and, therefore, the leach behavior not accurately predicted by the model.

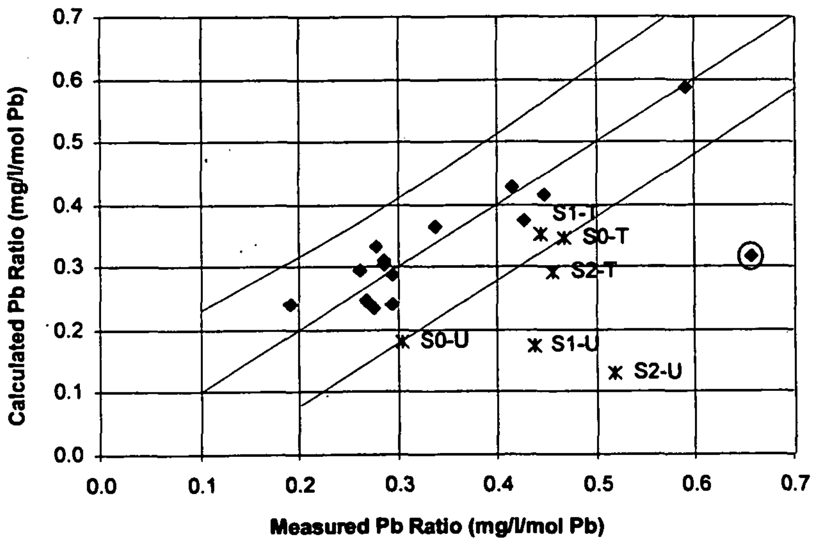

Figure 5-4. Calculated Lead Ratio versus Measured Lead Ratio for Glasses.

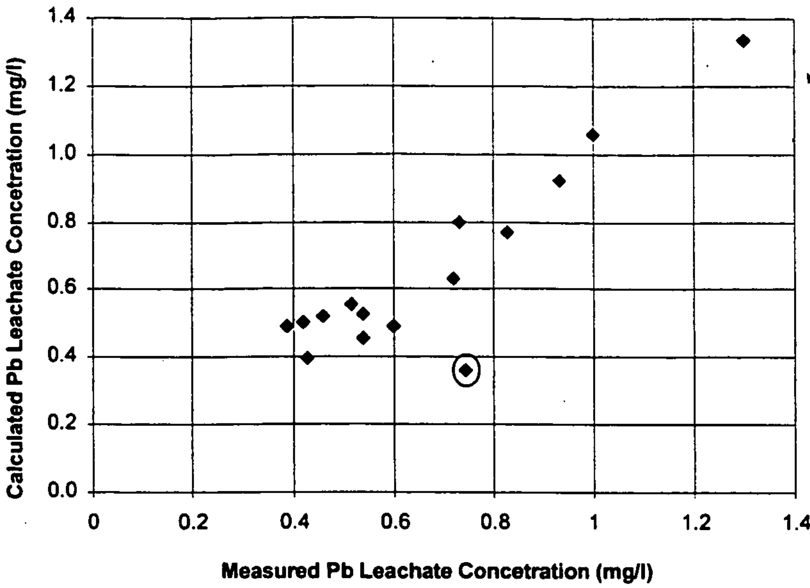

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Figure 5-5. Calculated Lead Leach Rate versus Measured Lead Leach Rate

5.2.4 Glass Melt Temperature

Glass compositions with acceptable melting temperatures, less than 1,300°C (2,372°F), were determined through a series of test melts. As an initial test, the surrogate material was melted without the addition of additives. The resulting melt temperature was in excess of 1,400°C, (2,552°F) which was much greater than the desired maximum temperature. A second set of glasses was prepared using alkali metal oxides, individually or in combination, to reduce the glass melt temperature. A reduction in the melt temperature was observed; however, the glass melts were still viscous in the desired temperature range. To further decrease the glass viscosity, alkaline earth metal oxides were identified as fluxes in combination with the alkali metal oxides. Test glasses indicated that alkali metal oxide concentrations in the range of 6.6-12.0 wt % and MgO+CaO concentration in the range of 8-13 wt % were sufficient for producing a glass with a melt temperature less than 1,300°C.

5.2.5 Procedure for Defining the Required Glass Compositions

The design criteria for suitable glass compositions from the various surrogate compositions was a combination of a suitable melt temperature and a suitable glass durability. The chemical durability criteria for the final glass composition was a lead leachate concentration below the criteria (2.5 mg/l for the present TCLP and 0.75 for the UTS limits). To meet the melt temperature criteria, the oxide concentrations of the alkali and alkaline earth metal oxides were adjusted into the ranges previously described.

The test glass compositions were determined using a computational method that combined the waste compositions, in an oxide form, with glass forming ingredients in proportions necessary to form a vitrifiable feedstock. Efficiency factors for the capture of various oxides into the glass were used to determine the amount of a specific oxide that would go into the glass or into the off-gas. These efficiency factors are based on Vortec Corporation's experience and are different for crucible melts and melts prepared in the Vortec CMS™. The resulting glass compositions were checked to ensure that the alkali and alkaline metal oxide concentrations were in the proper range to obtain the desired melt temperature. If the glass composition met these criteria, the glass composition was then entered into the durability model (discussed in Section 5.2.3) to determine if the TCLP lead leachate concentration met the desired criteria. It is observed that the increase of the alkali and alkaline earth metal oxides, which act as fluxes to reduce the melt temperature of the glass also decrease the glass chemical durability and increase the lead leachate concentration. See confirmation of this effect in Table 5-1 and as discussed in Section 5.1.2.

5.2.6 Laboratory Results-Surrogates and Target Glass Data

To help establish the glass compositions to achieve a given leachability and melt temperature, the oxide composition of the slurries must be established. Table 5-3 compares the compositions of the slurries in an oxide form derived from the data provided by FDF (DS, S1 and S2 surrogate definition). The concentrations of the majority of the components do not change significantly between the various slurries. This is especially true of the oxides with larger concentration, such as SiO_2, that amounted to almost 66% of the solid oxides in the slurries. The primary concentration difference among the slurries is the concentration of PbO, from 1.19 to 3.62 weight %. The concentration difference of the SO_2 is also significant since this component volatilized during the vitrification process.

Table 5-3. Oxide Compositions of Slurries for Vitrification

Oxide	DS Vitrification Slurry	S 1 Vitrification Slurry	S 2 Vitrification Slurry
SiO_2	18.93	18.65	18.56
Al_2O_3	1.37	1.25	1.37
Na_2O	0.59	0.46	0.44
K_2O	0.23	0.20	0.22
MgO	0.34	0.62	0.69
CaO	0.12	0.12	0.71
BaO	1.48	1.87	1.23
ZnO	0.00	0.00	0.00
NiO	0.12	0.13	0.10
PbO	3.62	3.62	1.91
Fe_2O_3	0.79	0.83	1.82
CrO_3	0.05	0.01	0.01
V_2O_5	0.02	0.02	0.02
P_2O_5	0.29	0.25	0.33
As_2O_5	0.03	0.00	0.04
SeO_2	0.02	0.02	0.02
H_2O	70.14	70.11	70.18
CO_2	0.30	0.29	0.83
SO_3	0.97	1.44	0.94
NO_2	0.15	0.07	0.15

Based on the consistency of the slurry compositions on an oxide basis (caused primarily by the large constant amount of SiO_2), the melting characteristics of the glass prepared from the different slurry formulations, using the same additives, were assumed to be the same. Using the glass durability model and initial laboratory melts, the major objective of the development process was reduced to achieve a reasonable glass melting temperature. As indicated in Table 5-4, the glasses developed in the laboratory using the method described passed the durability criteria. The single exception was the LAB-SI-U glass formulation.

Table 5-4. TCLP Results from Glass Samples Prepared in Laboratory

Analyte	LAB-SO-T	LAB-SO-U	LAB-S1-T	LAB-S1-U	LAB-S2-T	LAB-S2-U	One Half TCLP Limit	UTS Limit
Ag	<0.022	0.032	<0.022	<0.020	<0.020	0.022	2.5	0.14
As	<0.089	<0.088	<0.088	<0.087	<0.087	<0.087	2.5	5.0
Ba	0.61	0.26	1.3	0.55	0.50	0.45	50.0	21.0
Cd	<0.024	<0.023	<0.023	<0.023	<0.023	<0.023	0.5	0.11
Cr	<0.054	<0.053	<0.053	<0.053	<0.053	<0.053	2.5	0.60
Hg	<0.00075	<0.00075	<0.00075	<0.00075	<0.00075	<0.00075	0.1	0.025
Ni	0.042	<0.025	0.043	0.026	0.038	0.033	-	11.0
Pb	1.5	0.64	1.4	0.97	0.79	0.72	2.5	0.75
Sb	<0.098	<0.098	<0.098	<0.099	<0.099	<0.099	-	1.15
Se	<0.19	<0.19	<0.19	<0.17	<0.17	<0.17	0.5	5.7
Zn	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	-	4.3

LAB=Laboratory Preparation T=TC
SO=Demonstration Surrogate, S1=S1 Surrogate; S2=S2 Surrogate U=UTS

Table 5-5 summarizes the surrogate and glass forming components used to prepare glass in the laboratory. Tables 5-6a and 5-6b compare the calculated and measured compositions of the glass prepared in the laboratory. For the calculated compositions, it is assumed that all of the metal oxides are captured in the glass and all of the sulfate and water are volatilized from the glass melt. Also included in each table are remarks regarding the color of the glass, the waste loading, bulking factor, and the presence or absence on a sulfate layer for the glasses. The waste loading is calculated from the supplied waste compositions and the designed feedstock compositions. In these calculations, the assumption that all of the oxides would go into the glass was made. The bulking factor was calculated from bulk density measurements on frit samples prepared in the laboratory. The bulk densities measured on the frit prepared during the POP test corresponded to the measurements made on the laboratory prepared samples.

Table 5-5. Glass Feedstock Composition for Prepared Glasses

Slurry	DS	DS	Silo 1	Silo 1	Silo 2	Silo 2
Criteria	**TCLP**	**UTS**	**TCLP**	**UTS**	**TCLP**	**UTS**
Glass Label	**S0-T**	**S0-U**	**S1-T**	**S1-U**	**S2-T**	**S2-U**
Slurry (30% solids)	90.00%	80.00%	90.00%	80.00%	90.0%	85.00%
Soda Ash	2.75%	-	2.75%	-	2.75%	3.00%
Lithium Carbonate	2.75%	4.75%	2.75%	4.70%	2.75%	3.00%
Limestone	4.50%	5.75%	4.50%	5.30%	4.50%	4.00%
Sand	-	9.50%	-	10.00%	-	5.00%

Table 5-6a. Chemical Analysis Results from Glass Samples Prepared in Laboratory to Meet One-Half of the Present TCLP Limits (Composition Results in Wt %)

Analyte	LAB-SO-T		LAB-S1-T		LAB-S2-T	
	Calculated	Measured	Calculated	Measured	Calculated	Measured
SiO_2	55.97	56.9	55.02	58.4	55.76	59.8
Al_2O_3	4.04	4.21	3.70	4.35	4.11	4.70
Li_2O	3.65	3.47	3.64	3.46	3.71	3.51
Na_2O	7.02	5.94	6.63	5.29	6.69	5.25
K_2O	0.67	0.68	0.60	0.66	0.65	0.73
MgO	1.00	0.86	1.83	0.77	2.07	1.0
CaO	8.65	8.10	8.60	8.74	10.53	9.22
BaO	4.39	4.19	5.53	5.22	3.71	3.73
Fe_2O_3	2.34	4.15	2.46	2.59	5.48	5.77
Cr_2O_3	0.14	0.09	0.04	0.02	0.03	<0.01
NiO	0.35	0.35	0.37	0.38	0.31	0.33
PbO	10.72	10.8	10.68	10.7	5.74	5.99
ZnO	0.01	0.03	0.01	0.02	0.01	0.02
As_2O_3	0.09	0.10	0.00	0.03	0.11	0.10
P_2O_5	0.84	1.22	0.74	0.47	0.98	0.03
V_2O_5	0.07	0.08	0.07	0.07	0.07	0.03
SeO_2	0.05	0.013	0.07	0.013	0.05	0.126
SO_3		1.48		1.27		1.37
Color		Brown		Brown		Brown
Waste Loading		89%		89%		90%
Bulking Factor		0.9		0.9		0.9
Sulfate Layer		Yes		Yes		Yes

Table 5-6b. Chemical Analysis Results from Glass Samples Prepared in Laboratory to Meet the Proposed UTS Limits (Composition Results in wt%)

Analyte	LAB-SO-U		LAB-S1-U		LAB-S2-U	
	Calculated	Measured	Calculated	Measured	Calculated	Measured
SiO_2	66.54	67.5	66.76	65.8	61.93	67.3
Al_2O_3	2.95	3.66	2.69	3.07	3.46	3.69
Li_2O	5.18	4.88	5.09	4.93	3.61	3.43
Na_2O	1.27.	1.36	0.99	1.12	6.34	5.10
K_2O	0.49	0.55	0.44	0.55	0.55	0.60
MgO	0.73	1.13	1.33	0.71	1.74	0.78
CaO	8.96	8.32	8.20	8.04	8.47	7.36
BaO	3.20	3.18	4.01	3.91	3.12	3.15
Fe_2O_3	1.71	1.80	1.78	1.90	4.62	4.96
Cr_2O_3	0.10	0.07	0.03	0.02	0.03	<0.01
NiO	0.26	0.26	0.27	0.28	0.26	0.21
PbO	7.83	7.62	7.76	7.82	4.84	4.98
ZnO	0.01	0.03	0.01	0.02	0.01	0.02
As_2O_3	0.06	0.08	0.00	0.03	0.09	0.10
P_2O_5	0.62	0.59	0.54	0.26	0.82	0.21
V_2O_5	0.05	0.05	0.05	0.06	0.06	0.02
SeO_2	0.04	0.008	0.05	0.004	0.04	0.011
SO_3		1.56		2.00		1.24
Color		Brown		Brown		Brown
Waste Loading		65%		65%		76%
Bulking Factor		1.3		1.3		1.1
Sulfate Layer		No		No		No

5.2.7 Lessons Learned During the Formulations Effort

During the laboratory melting procedure, the importance of controlling the redox state of the glasses was observed. In several of the glasses, a sulfate layer formed on the surface of the glass melt during the melting process. A low viscosity liquid layer on the surface of the glass melt characterized the sulfate layer. In some cases reductants were added to the glass batch to aid in the destruction of the sulfate layer. However, over reduction (the addition of too much reductant to the feedstock) resulted in the formation of lead metal nodules that settle to the bottom of the crucible. TCLP results on glasses with lead nodule formation showed a greater than expected lead-leachate concentration. Working with several melts, it was determined that the best way to remove the sulfate phase was to pour off the fluid on the surface of the melt. Using this method eliminated the addition of reductants to the glass feedstock. It should be noted that sulfate layers are not a problem with the CMS™ technology since the sulfur is volatized and captured in the APC.

S1 and S2 surrogate materials were premixed by FDF. However, the top size of the silica included in these surrogates exceeded 50 mesh. This coarse silica in the glass melt does not allow for complete dissolution of the silica in a reasonable amount of time. As a result, when the melt is cooled it will contain chemically different phases, i.e., silica rich and silica poor phases. The silica poor phases tend to have lower chemical durability than the silica rich phases. The low durability phases tend to dominate the leaching characteristics of the material. Therefore, a greater than desired lead leaching rate was encountered in the S1 glass developed to meet the UTS standard (S1-U).

6.0 DESIGN PRELIMINARY FULL-SCALE DESIGN

Vortec and FWE prepared a preliminary design for a full-scale system that has the capacity of processing 6,780 m^3 of combined processed uranium ore residue and Bento Grout™ from Silo 1 and Silo 2 over a three year period. The operating schedule for the plant will be 7 days a week, 24 hours a day, and 41 weeks per year with an effectiveness of 90%, for approximately 70% overall availability. The process will be capable of converting residue that is contaminated with RCRA metals and radionuclide constituents into a vitrified product that will pass the Nevada Test Site's (NTS) Waste Acceptance Criteria (WAC) while complying with all of the governing state, federal and local regulations.

6.1 DESIGN REQUIREMENTS DOCUMENT

The Systems Requirements Document (SRD) for the full-scale vitrification plant is a common record of all functional and performance requirements, design constraints, interface definitions, and acceptance criteria established for the preliminary full-scale design. The SRD includes appropriate system requirements and regulations as defined by FDF. The SRD is included in the FWE full-scale Design Report in Appendix C, Section II.

6.1.1 Vortec Requirements

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The plant's average processing capacity is nominally 1,155 lb/hr of residue, dried to 5% moisture. The principle system requirements for the plant to accomplish this processing rate are as follows:

1. The system is designed to receive 10-30 wt % solids slurry from the TTA. For the purpose of this preliminary design, the composition is assumed to be approximately as provided by FDF for Silo 1 or Silo 2 surrogates. In addition Vortec and FWE reviewed the Silo 1 and 2 Accelerated Waste Retrieval Project Report-Technical Requirements Document, and Florida International University study to establish the approximated waste steam characteristics.
2. The nominal processing capacity of the feed preparation system will be 8,000 lb/hr of combined Silo 1 and Silo 2 residue and Bento Grout™ per year based on an operational schedule of 8 hours/day, 4 days/week.
3. The targeted final waste form is a glass that meets a licensed disposal facility's WAC.
4. The waste received from the TTA is in slurry form. The CMS™ plant will dry it to 5% moisture. Size reduction will occur in a grinding operation immediately after the drying operation. Additives required to form a product glass will be introduced into the dried slurry in a blend tank located after the grinding operation. The combined dry feed will be introduced into the reactor by means of an injector.
5. The system produces a glass frit, a chemically stable final waste form, that will pass the TCLP criteria for being classified non-hazardous.
6. The system will be designed to reduce the amount of secondary waste produced by recycling material into the melter.
7. The system will comply with all applicable federal, state, and local health, safety and environmental regulations.
8. The Air Pollution Control (APC) system will include a partial quench of the flue gas to 450°F, a bag filter, and two stages of scrubbing to meet the flue gas requirements. The conditioned flue gas is then passed to the Radon Control System (RCS) to remove radon.
9. The system will be designed to recycle glass that does not meet disposal criteria.
10. The full-scale vitrification facility will be constructed at the Fluor Daniel Fernald site.

6.1.2 FDF's Requirements

FDF also listed specific requirements as follows:

Vitrified Product

The CMS™ will process the untreated Silo 1 and Silo 2 waste into a product that meets the following requirements;

1. Appearance: uniform and homogeneous
2. Compressive strength: 50psi
3. Standing liquids: none

4. Leaching characteristics: Leach rate 50% of 40 CFR 261 requirements
5. Limited dusting: treated waste contains less than 1% particulate with diameters of 10 microns or less.
6. Not classified as a hazardous waste: Passes TCLP test as defined in 40 CFR 261.

Air Emissions Control

The APC system will utilize Best Available Technology (BAT). In this case, the APC system will include a partial quench to 450°F, bag filters, two stages of scrubbing for NOx and SOx control, followed by carbon beds for radon control. Expected air emissions, as established by FDF for conditions prior to the carbon beds, are as shown in Table 6-1.

Table 6-1. Off Gas Contaminants to the RCS

CO_2	10% V
NO_x	20 PPMV
SO_x	20 PPMV
Humidity	0.021 /pound of gas
Particulate	Bag House 99.5% Efficient
Flow rate	500 scfm
Temperature	< 90°F
Radon	500,000 pCi/liter
Total Organics	40 PPM

Wastewater Control

Water removed from the slurry in the centrifuges is recycled back to the TTA. Radon will be captured by dissolution in water.* Water evaporated from the slurry in the heated screw drying system is condensed and recycled to the evaporative cooler in the APC system. The centrifuges and the condensate tank are vented to the CMS™, ultimately sending these small vent flows to the APC system and then to the RCS.

The wastewater is filtered to remove total suspended solids (TSS) to a concentration below 1,000 PPM. Allowable levels of contaminants to the Fernald Advanced Water Treatment (AWWT) system are given in Table 6-2.

*Reference: J.D. Lowry, W.F. Brutsaert, T. McEnerney, and C. Molk "Point of Entry Removal of Radon from Drinking Water" Journal of American Waste Water Association, vol. 79, pg. 162, 1987.

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Table 6-2. Waste Water Contaminants

Metals	Discharge Limits mg/L	Radionuclides	Discharge Limits pCi/L
Arsenic	5.0	Actinium-227	10
Barium	100.0	Lead -210	30
Cadmium	1.0	Polonium-210	80
Chromium	5.0	Protactinium-231	10
Lead	5.0	Radion-226	100
Mercury	0.046 PPM	Radium-228	100
Selenium	1.0	Thorium-228	400
Silver	5.0	Thorium-230	300
Iron	N/A	Thorium-232	50
		Uranium-234	5000 PPM
		Uranium-235/236	Total U
		Uranium-238	

6.2 Design Issues

6.2.1 Refractory Consumptions

The refractory installed in the Vortec pilot unit during the POP test was predominantly AZS material (alumina/zirconia/silica). This selection was based on favorable thermal shock properties as well as being a good general service refractory for a variety of glass compositions.

Refractory selection is a detail design issue. No inference about refractory wear in a full-scale design should be made from the results of the POP test. For the commercial unit, refractory selection will be part of a detailed design exercise that includes a determination of the best candidates from a chemical compatibility standpoint and consideration of mechanical properties. Dynamic (stirred) finger testing will also be performed prior to selection.

6.2.2 Sulfate Accumulation-Lead Recycle

The carryover from the melter (predominantly lead sulfate) will be recycled back to the CM component of the CMS™. Recycling to the melter as opposed to recycling through the CRV reactor is accomplished to minimize re-volatilization of the lead. The recycled lead sulfate will decompose in the CM and a portion of the lead will be incorporated into the glass adding to the lead incorporated in the CRV stage. The balance of the recycled lead will re-volatilize. The glass will be saturated with SO_3; therefore, the recycled sulfur will leave the CM as SO_2 gas. The off-gas leaving the CM will contain lead and sulfur in the gas phase from both incoming feed materials and the recycle stream. The volatilized lead and the SO_2 will recombine when the off-gas is cooled through the evaporative cooler. The resulting $PbSO_4$ will be collected in the bagfilter and again enter the recycle loop. When the system reaches steady state, there will be on the order of 300-400 lb/hr of lead sulfate recycling back to the CMS™. The amount of SO_2 gas leaving the bagfilter and entering the SO_2 scrubber will approach the feedrate of sulfur to the CMS™ (about 26 lb/hr as SO_2). The sulfur leaves the scrubbing system as Na_2SO_4. About 55 lb/hr of Na_2SO_4 and 1,935 lb/hr water are sent to the AWWT.

6.2.3 Injector Design

The dry feed injector to be used for the full-scale design will not experience the high erosion rate. The feed velocity in the dry feed case will be considerably lower than those in the POP injector since atomization is not required. In addition, the material of construction would be different. The injector design for the 72-hour test specified silicon carbide, but the fabricator was unable to provide the required material in time for the test. As an expedient, stainless steel was substituted knowing that some wear would be experienced.

6.3 FULL-SCALE PROCESS DESCRIPTION

Figure 6-1 presents the process flow block diagram for the full-scale application of the CMS™ technology to the remediation of the Fernald silo residue. The CMS™ vitrification plant includes the following sub-systems:

1. Feed Preparation System
2. Slurry Delivery System
3. Slurry Pretreatment
4. Additives Preparation System
5. Vortec CMS™
6. Air Pollution Control System
7. Vitrified Product Handling System
8. Waste Water Treatment
9. Instrumentation & Control System
10. Recycle Conveyor
11. Reprocessing System for Off-Spec Frit
12. Utilities System

It should be noted that changes in feed characteristics are handled proactively through sampling, analysis and adjustments in batch chemistry to maintain required glass chemistry. The CMS™ technology is especially adept at responding to changes in feed chemistry as illustrated by the temperature-time history developed during the POP test. Sufficient storage of dried & sized silo residue are maintained to accomplish this objective. Analysis of the product glass by XRF would be incorporated to allow another level in real time glass chemistry adjustment.

CMS™ process control is primarily one of temperature control. This begins with a consistent feed rate of feedstock materials. Fuel and air/O_2 are adjusted to maintain temperature set point. As demonstrated during the demonstration test, upsets (loss of feed for example) are easily accommodated with respect to maintaining temperature (see process logs in the data package deliverable and the test report). A low inventory of glass contributes to ease of temperature control as well as minimizing production of "off-spec" material, should it occur.

The following sections describe the individual subsystems in detail.

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Vortec Corporation

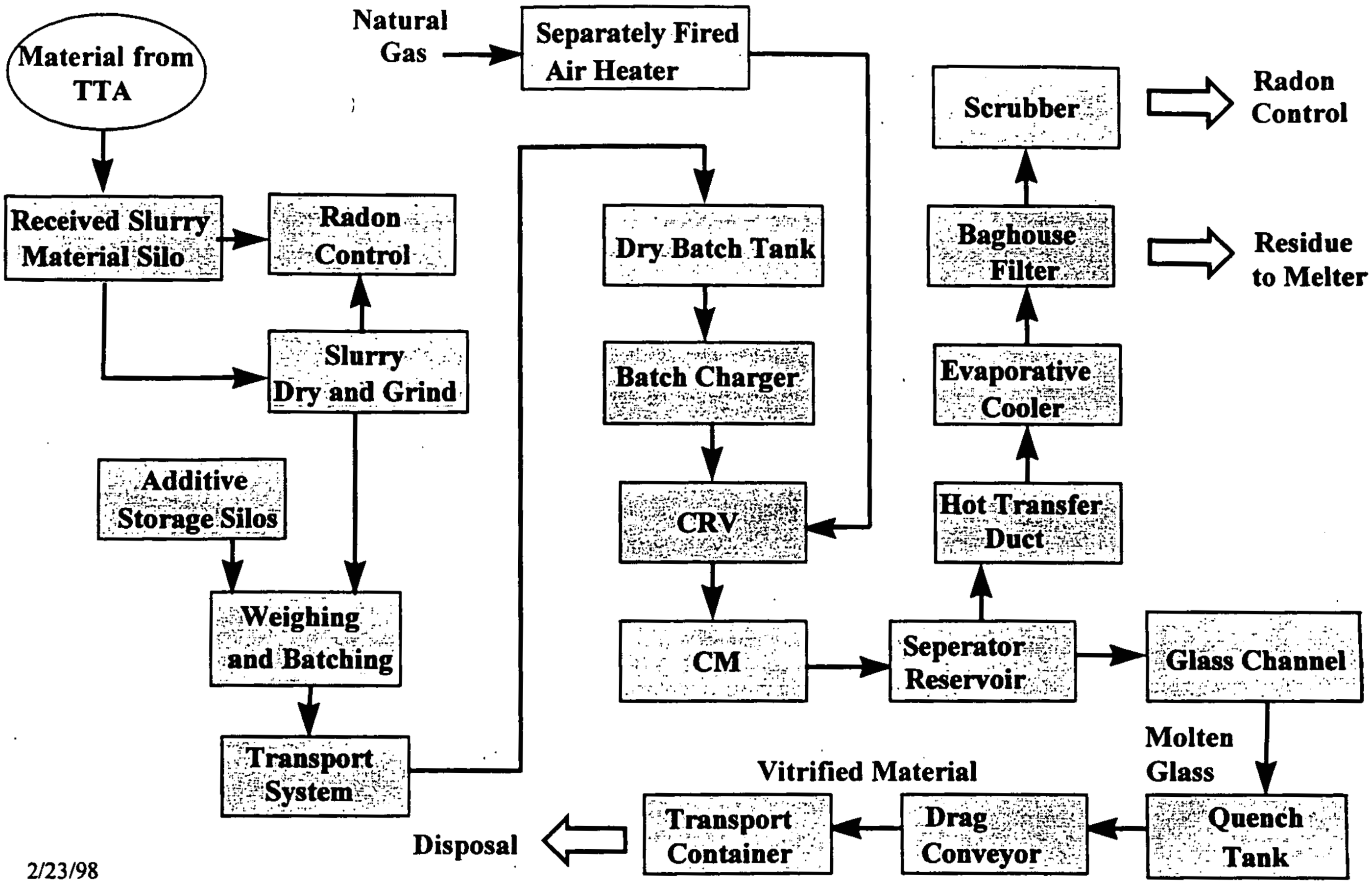

Figure 6-1. Full-scale Process Flow Diagram

6.3.1 Feed Preparation System

The size of the slurry-receiving tank is based on the processing rates of the Accelerated Waste Retrieval Project. As an estimate for a three-year processing period, one 8,000 gallon tank with agitators is specified. Dry material silos are provided for the additives needed to produce the glass product. Pneumatic truck delivery of these ingredients is assumed with a sufficient area to be provided for truck access.

6.3.2 Slurry Delivery System

Slurry from the tank retrieval system will be fed to the slurry pretreatment system by means of a pump and metering system. The type and size of the pump was selected based on the best available slurry characteristic data and the required flow rate and pressure.

6.3.3 Slurry Pretreatment

The Vortec full-scale system will de-water the as-received slurry using two centrifuges and two heated screw dryers to dry the material to 5% moisture. The water removed from the slurry is re-circulated to the silo waste retrieval system for slurry generation. The dried material is expected to be unconsolidated with particles as large as 0.25 inches. This material will require grinding to reduce its top size to 600 microns.

The dried silo residue will be stored in three silos providing up to seven days of storage capacity. This storage allows time for sampling and chemical analysis of each silo's contents. Sampling occurs periodically during filling to ensure that a composite of the entire silo contents is obtained. A 24-hour turnaround for chemical analysis is allocated. The analysis will be input to the control system database and used to adjust the ratio of additives when blending the final feedstock to the process.

6.3.4 Additives Preparation System

The additives preparation system meters, blends, and delivers the dry glass additives to the weighing and batching system. The system includes a weigh hopper, blender, and blended material storage. Dried tank residue and the glass additives are combined in the batch blender before being injected into the CRV reactor.

6.3.5 Vortec CMS™ System

Preheated air and fuel are introduced into the CRV reactor through tangential inlets. The inlets are configured to produce two counter-rotating flow streams in the upper section of the CRV reactor, promoting intense turbulence and thus efficient heat transfer in this region. Blended dried silo waste and glass formed additives are introduced into the top of the CRV reactor, along the longitudinal centerline by means of an injector. The average gas-solids suspension temperature leaving the CRV reactor is typically 2,000°F to 2,700°F, depending on the feedstock melting characteristics. The process air is preheated in a separately fired air heater that is a standard component in the glass industry.

The preheated solid materials exiting the CRV reactor enter the CM where they are separated to the wall, to form a molten liquid glass layer. The glass produced and the exhaust products exit the CM through an exit channel and enter the glass S/R. The molten glass in the reservoir is delivered to a glass channel and subsequently to the quench tank. The exhaust gases from the process are treated by an APC system.

Oxygen enrichment in the Vortec CMS™ reduces the requirement for natural gas which in-turn reduces the amount of off-gas produced. It is anticipated that the oxygen will be supplied by a conventional liquid storage tank and vaporizer system. Alternatively, a Vacuum Pressure swing Absorption (VPSA) system could be evaluated for on-site generation of oxygen, although, at the modest consumption rates for this project, the scale is probably not economical.

The oxygen system would include a remotely located liquid storage tank, vaporizer, and appropriate safety systems. An O_2 line would enter the CMS™ building and feed a distribution manifold. The O_2 would be piped to three different locations on the CRV reactor. The O_2 will be added at the point of feedstock injection, with the lid reactor air, and with the inlet arm air. The O_2 additions to the air will occur after preheating in the indirectly fired air heater. The overall enrichment level will be 30% by weight oxygen in air (compared to 23.1 weight percent in normal air).

6.3.6 Air Pollution Control (APC) System

The gases from the CMS™ process leave the S/R and enter the APC system. The purpose of the APC system is to remove contaminants from the process off-gas to meet emission limits at the stack. The APC system consists of a partial quench evaporative cooler followed by a bag filter and two stages of gas scrubbing. The gases then enter the carbon beds that are supplied by FDF for radon control.

The off-gas temperature leaving the evaporative cooler is sufficiently high so that the system stays above the dew point through the bagfilter. The gas becomes saturated in the scrubbing system and the final off-gas is chilled to condense the water and meet the specified humidity to the carbon beds.

The amount of CO_2 generated will be a function of the natural gas firing rate. Maximum firing occurs at the end of a campaign when heat loss is the highest. This firing rate was used for design purposes so that excess CO_2 values should never occur with appropriate system maintenance. In addition, within the range of oxygen enrichment allowed for design purposes, O_2 enrichment levels can be used to control CO_2 by eliminating some of the N_2 heating load and, therefore, reducing the natural gas firing requirement and resultant CO_2 generated.

Particulate collected from the bag filter will be transported to the CM and re-injected into molten glass layer in the melter (see discussion relating lead capture and SO_2 removal).

6.3.7 Vitrified Product Handling System

Vortec consistently water quenches the molten glass to form a frit. This quenching operation quickly changes the state of the glass from a high temperature liquid to a cooled solid. As in the commercial operations, adjusting the speed of the drag conveyor ensures that frit deposited in the shipping container is dry. The residual heat in the frit is used to evaporate any moisture remaining with the frit upon leaving the quench tank. The safety advantage of operating around a cool solid is obvious when compared with the handling of a partially solidified monolith of glass.

Vortec's justification for preferring a frit final waste form is based partially on its own operating experience and on preliminary data presented in FDF report "Vitrification Waste Form Engineering Study", Report Number 40430-ES-0002 Rev B. Table 6-3 is a comparison for the cases where the glass product is sent to the repository as a frit and as a monolith. The cost to deposit the same quantity of glass in the NTS appears to be approximately $1.5 million more for glass as frit than as a monolith. However, to produce a monolith the equipment shown in Table 6-4 must be provided at the processing plant.

Table 6-3. Burial Cost Comparison, Frit vs. Monolith

	Monolith	Frit (Cullet)
Number of boxes	3436	3625
Size of Box Ft^3	122.6	157.7
Cost of Transport @ $3400/Truck Load, 2 Boxes to a Load	$5,841,200	$6,162,500
Cost to Bury @ $7.50 Ft^3	$3,159,402	$4,287,468
Total Cost	$9,000,602	$10,449,968
Increased cost		$1,449,366

Table 6-4. Equipment Comparison, Frit vs. Monolith

Requirements	Monolith	Frit (Cullet)
Pouring		
Metal Transfer Canister	Yes	No
Hydraulic Lift Station	Yes	No
Fork Lift	Yes	Yes
Cooling		
Cooling Room with 48 Stations	Yes	No
3 Ton Bridge Crane	Yes	No
Two 8000 acfm Once through HVAC Systems	Yes	No
HEPA Filters	Yes	No
Recycling When Needed		
Remote Removal Equipment	Yes	No
Crushing Operation	Yes	No
Grinding Operation	Yes	Included in Feed Preparation System

Although no cost estimates were made for the equipment, one would expect that a room with a cooling capacity of 900,000 Btu/hr containing a 3 ton bridge crane built to DOE specification would use up most of the $1.5 million cost difference listed in Table 6-3.

Reprocessing off-specification frit requires discharging the material already loaded in the FDF shipping container on a conveyor and transporting it to the grinding operation in the feed preparation system. Reprocessing the frit through the hammer mill (that is already operating) will produce a glass of the required size for ease of re-melting. Adjusting the rate of combining the re-sized frit with the incoming dry feed will assure a glass that meets specification.

In addition to the above mentioned capital equipment items, the health and safety considerations of operating with a monolith in its partially solidified conditions and radiation exposure considerations will also increase the cost of the monolith option.

6.3.8 Consumables and Secondary Waste

As indicated in Table 6-5, over the three-year campaign to vitrify the residue in Silo 1 and Silo 2, approximately 9,955 tons of dry material will be processed. If the residue is received from the TTA as 30% solid slurry, then 33,333 tons of slurry will be received by the vitrification system. Glass additives in the amount of 4,084 tons will be added, and it is estimated that 4,236 tons of captured material will be recycled back into the glass. Based on the proposed system 11,437 tons of glass would be produced (waste loading dry solids to glass of approximately 88%). It is estimated that 2.5 lb/hr of metal oxides at 50% solids will be generated for which a disposal method will be identified in the detail design phase. An additional unknown amount of personnel protection equipment (PPE) will also require a disposal method. With proper shredding equipment, this PPE could be disposed in the CMS™. Refractory materials can also be processed through the CMS™ for disposal during a demolition and decontamination phase.

6.4 AVAILABILITY FACTOR

Vortec estimated a system availability of approximately 70% based on 24 hours per day, 7 days per week, 41 weeks per year with an efficiency of 90%.

6.5 REVIEW OF THE REGULATORY REQUIREMENTS

Several EPA, OSHA, and DOE regulations apply to the proper design and operation of the full-scale remediation plant. The most prominent requirements are found in Table 6-6.

Table 6-5. Consumables and Secondary Waste Flow rates

Component	
Residue	
Silo Residue	9,735 Tons
Bento Grout™	220 Tons
Total Dry Residue	9,955 Tons
Total Slurry from TTA	33,333 Tons
Additives	
Li_2CO_3	1,021 Tons
Na_2CO_3	1,021 Tons
$CaCO_3$	2,042 Tons
Total Glass Additives	4,084 Tons
Recycled Material from Bag Filter	4,236 Tons
Total Solids to CMS™	18,275 Tons
Glass Produced	11,437 Tons
Consumables	
Fuel (Natural Gas)	222 lb/hr
Oxygen	830 lb/hr
Secondary Waste	
Na_2SO_4 to AWWT	54.9 lb/hr
Metal Hydroxides	2.5 lb/hr
Flue Gas to RCS	

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Table 6-6. Regulatory Review

Regulation	Primary Requirements
33 CFR 330	National Permit Program (Not Applicable)
40 CFR50	Air Quality (Final Design)
40 CFR Part 122	NPDES
40 CFR Part 125 Subpart K	Criteria and Standards for BMPs
40 CFR Part 61 Subpart Q	National Emissions Standards for Radon Emissions from DOE Storage and Disposal Facilities
40 CFR 125 Subpart K	Criteria and Standards for BMP's
40 CFR 191 Subpart A	Environmental Standards for Management and Storage
40 CFR 192	Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings
40 CFR 262	Standards for Generators of Hazardous Waste
40 CFR 264 Subpart B	General Facility Standards
40 CFR 264 Subpart C	Preparedness and Prevention
40 CFR 264 Subpart D	Contingency Preparedness
40 CFR 264 Subpart G	TSDF Closure and Post-Closure (Final Design Issue)
40 CFR 264 Subpart I	Use and Management of Containers
40 CFR 264 Subpart S	Corrective Action For Solid Waste Management Units (Not Applicable)
40 CFR 264 Subpart J	Tank Systems
40 CFR 264 Subpart X	Miscellaneous Units
40 CFR 264 Subpart DD	Containment Buildings
40 CFR 1500-1508	NEPA
40CFR 268 Subpart D	(Not Applicable)
40CFR 370	See OHSA Requirements
50CFR 402	Endanger Species Act (Not Applicable)
10 CFR 1022	Compliance with Floodplain/Wetlands Environmental Review Requirements
10 CFR 835	Occupational Radiation Protection (Other regulations that FEMP will comply with during remediation of Silo 1 and 2)
10 CFR 1021.0	NEPA
29 CFR 1910.132-140	OSHA (Other regulations that FEMP will comply with during remediation of Silo 1 and 2)
29 CFR 1910.1096	Ionizing Radiation
29 CFR 1910.1200	Hazard Communication
29 CFR 1940.1450	Chemical Hygiene Plan
29 CFR 1960	Safety and Health Program
DOE Order 450.2A	Identifying, Implementing and Complying with Environmental, Safety and Health Requirements
DOE Order 5400.5	Radiation Protection of the Public and the Environment
DOE Order 5480.4	Environmental Protection, Safety, and Health Protection Standards
DOE Order 5480.19	Conduct of Operations Requirements for DOE Facilities
DOE Order 5484.1	Environmental Protection Safety, and Health Reporting Requirements
DOE Order 5820.2A	Radioactive Waste Management
DOE Order 430.1	General Design Criteria
AOAC 3745-1-04	Ohio Water Standards
AOAC 3745-1-07	Ohio Water Standards (Not Applicable)
AOAC 3745-9-10	Ohio Well Water Standards (Not Applicable)
AOAC 3745-17-08	Control of Fugitive Dust (During Construction Only)
AOAC 3745-15-07	Prevention of Air Pollution Nuisance (Not Applicable)
AOAC 3745-17-07	Control of Particulate Emissions from Stationary Sources
AOAC 3745-31-05(A)(3)	Permit to Install
AOAC 3745-17-11	Restrictions on Particulate Emissions from Industrial Processes

6.6 CONSTRUCTION SCHEDULE

Construction will be completed within 28 months after contract go-ahead as shown in Figure 6-2. A readiness review will be initiated at the completion of construction and is estimated to require 4 months beyond the end of construction to complete. Readiness review preparations will be initiated 9 months before the end of construction to assure that all of the operation maintenance and health and safety documentation is in place at the beginning of the readiness review period. Completion of the readiness review will initiate hot start-up and the processing of Silos 1 and Silo 2 residues. Operations will continue for the next 36 months, thereby completing the total project in approximately 68 months. Table 6-7 represents the major milestones in the silo residue remediation project.

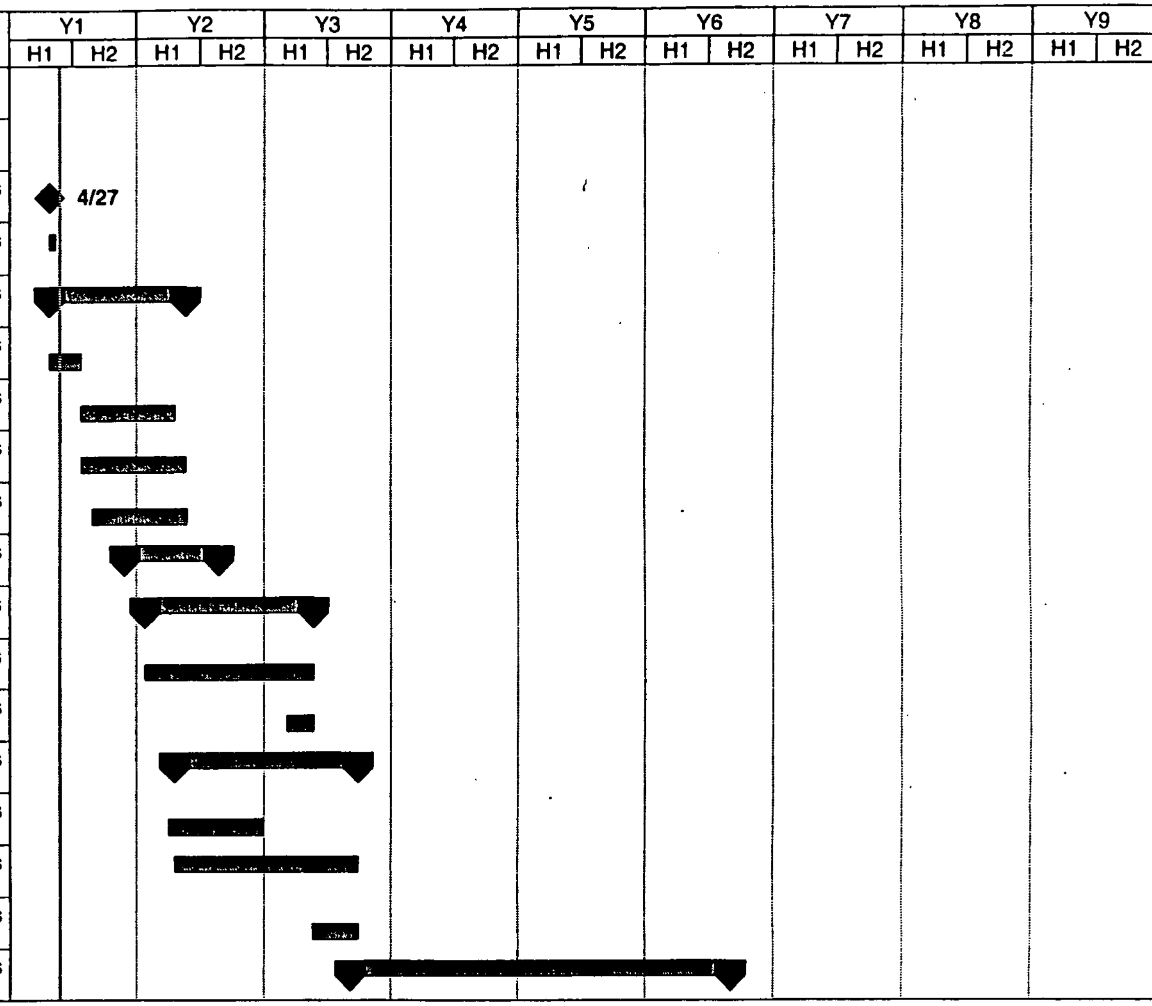
6.7 FULL-SCALE PLANT GENERAL ARRANGEMENT

It is assumed that the full-scale plant will be constructed on FDF property on a location to be determined. The preliminary full-scale general plant arrangement shown in Figure 6-3 a, b, c, d and e illustrates a configuration with open structures.

Table 6-7. Full-scale Project Key Milestones

Item	Activity	Occurrence (Weeks)
1	Award Contract	0
2	Conceptual Design Completed	15
3	Balance of Plant Engineering Completed	54
4	Regulatory Processes Completed	58
5	Plant Construction Completed	127
6	Hot Start-up Testing Completed	127
7	Readiness Review Completed	143
8	Silo 1 & 2 Residues Completed.	302

ID		Task Name	Duration
1			
2			
3		**Project Go-Ahead**	0 days
4		Project Management /Adminstration	14 days
5		**Task 1 Design**	280 days
6		Conceptual Design	13 wks
7		Final Design	39 wks
8		Regulatory Process	43 wks
9		Procurement/Construction Award	39 wks
10		**Task 2 - Procurment**	39 wks
11		**Task 3 Construction / Start-up**	345 days
12		Construction	69 wks
13		Start Up	11 wks
14		**Task 4 Readiness Review**	376 days
15		Preparations	39 wks
16		Safety Base Documents	376 days
17		Readiness Review	19 wks
18		**Task 5 Operations**	780 days



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Project: Frenald Project
Date: Mon 5/24/99

Task
Split
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Split
Rolled Up Milestone
Rolled Up Progress
External Tasks
Project Summary

Figure 6-2. Full-scale Plant Construction Schedule

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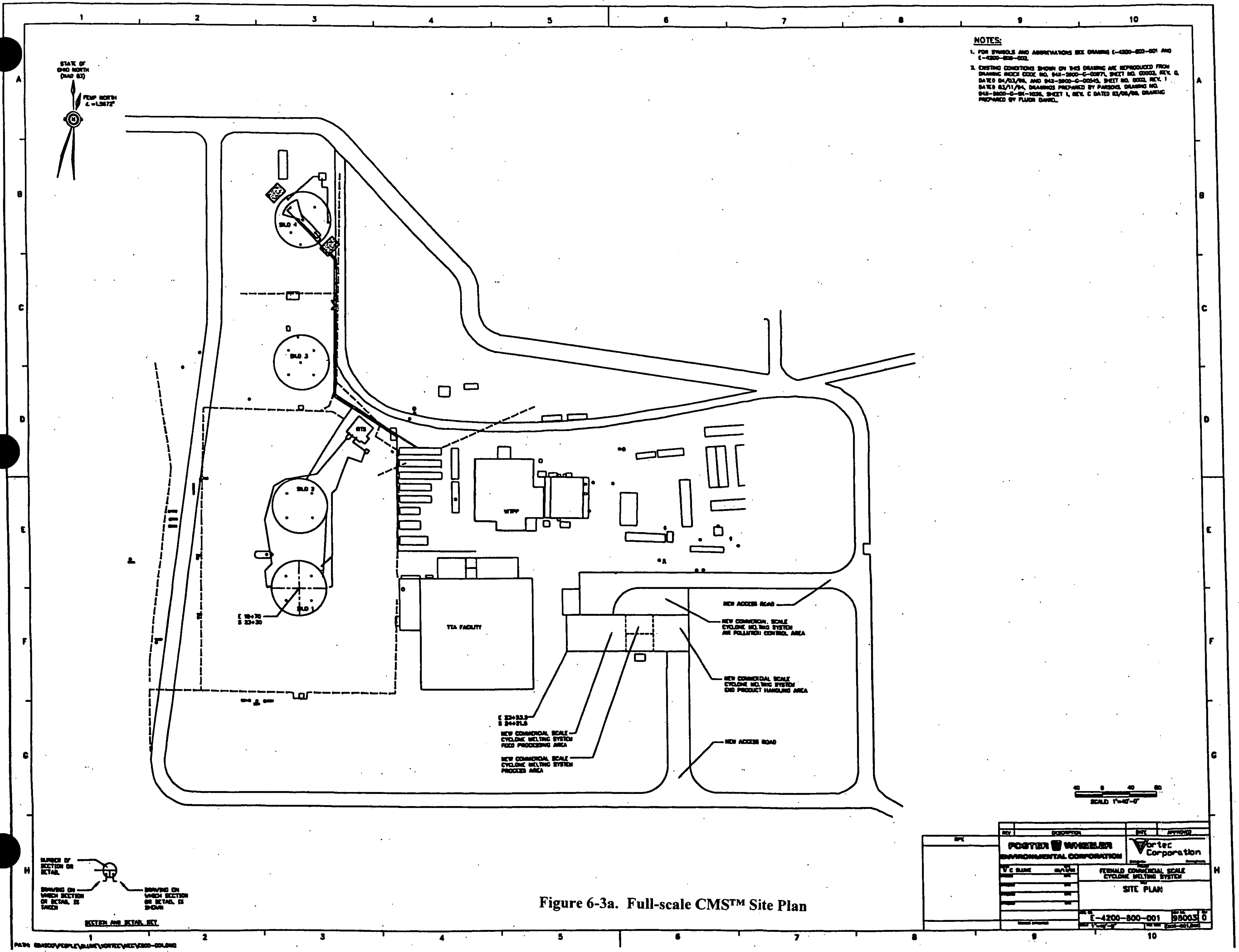

Figure 6-3a. Full-scale CMS™ Site Plan

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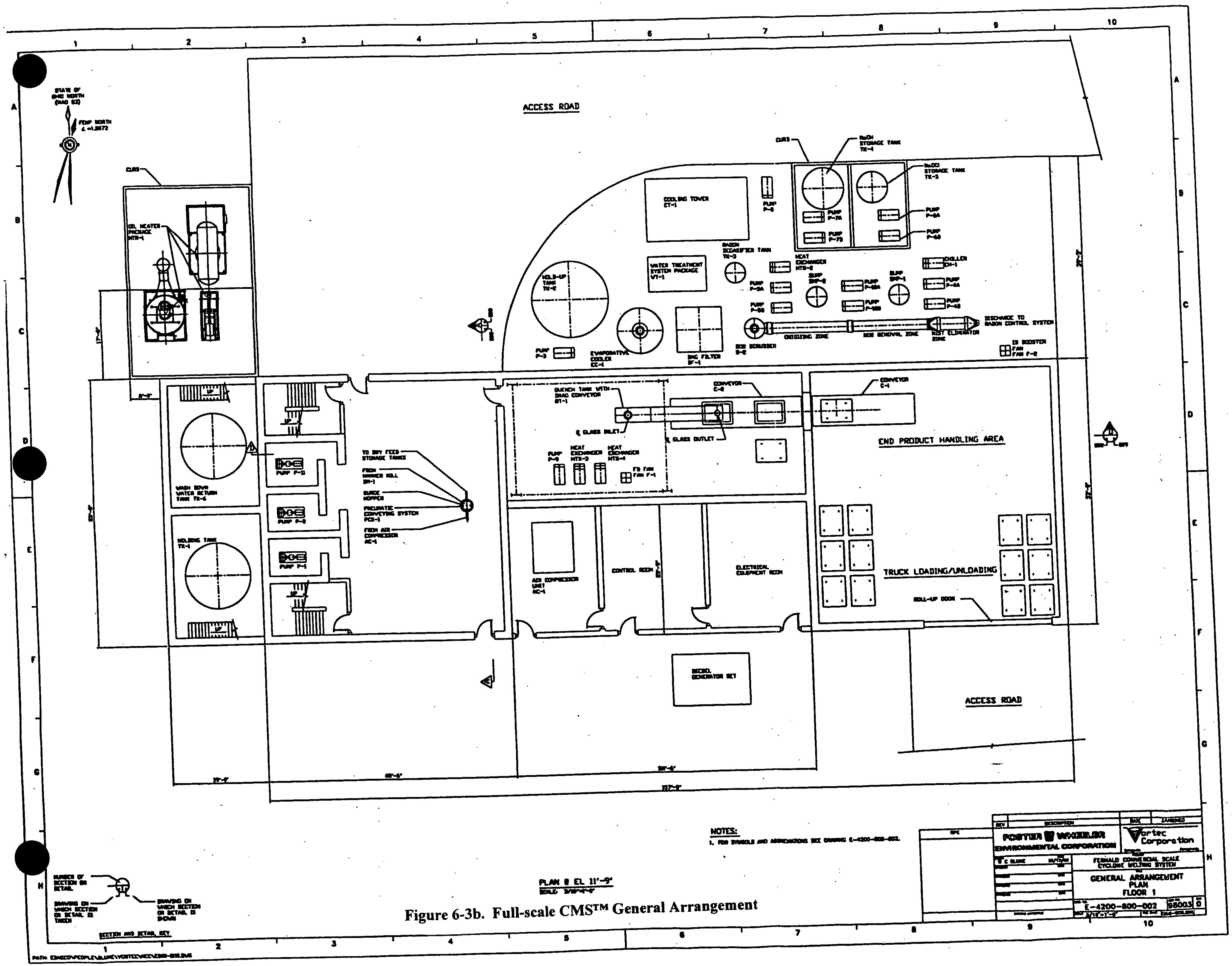

Figure 6-3b. Full-scale CMS™ General Arrangement

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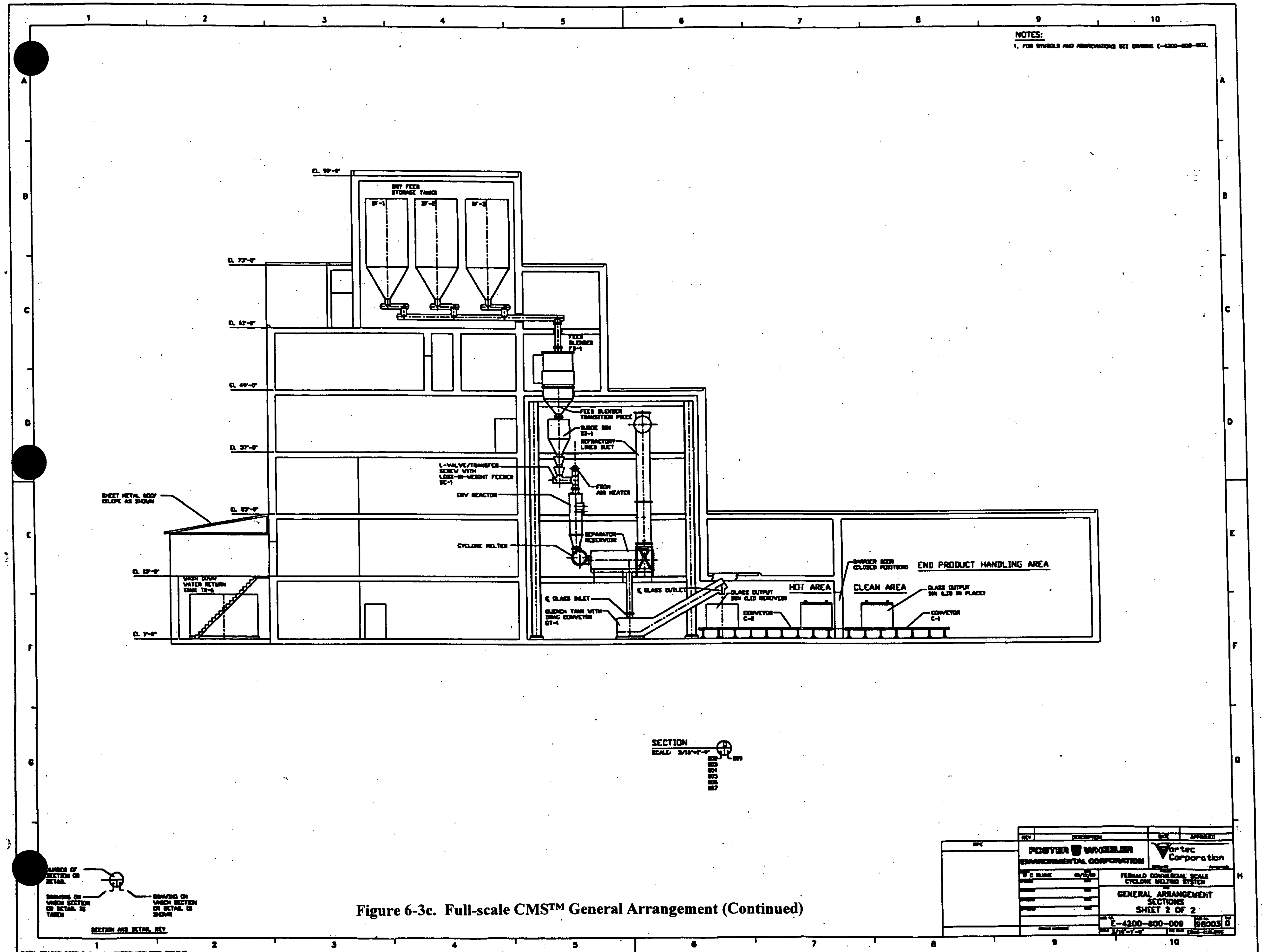

Figure 6-3c. Full-scale CMS™ General Arrangement (Continued)

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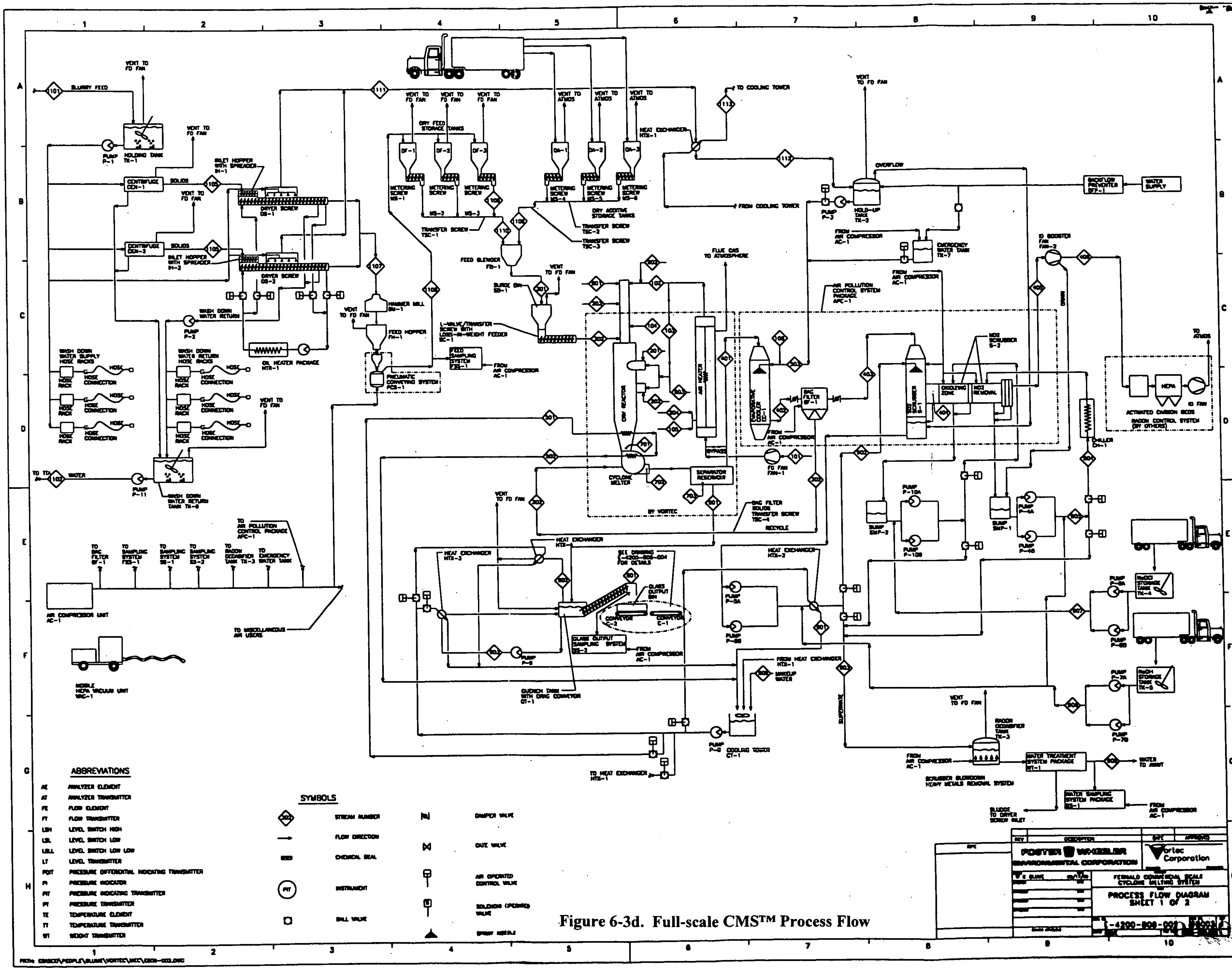

Figure 6-3d. Full-scale CMS™ Process Flow

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GENERAL NOTES:

Cyclone Melting System		101 Reactor Air to be Heated	102 Heated Air to Lid	103 Heated Air to Arms	104 Transport Air	105 Air to Air Heater Burner	201 Natural Gas to Arm A	202 Natural Gas to Arm B	203 Natural Gas to Lid	204 Natural Gas to Air Heater Burner	701 CRV Reactor	702 Cyclone Melter	703 Separator Reservoir	801 Oxygen to CMS Inlet	802 Oxygen to Lid	803 Oxygen to Arms
Mass Rate	lb/hr	2434	583	1704	148	780	60	60	52	42	4674	4674	4674	165	40	32
Density	lb/ft3	0.076	0.025	0.025	0.079	0.076	0.045	0.045	0.045	0.045	0.0139	0.0138	0.0137	0.084	0.084	0.084
Flow	acfm	531	391	1145	31	170	22	22	19	15	3782	3810	3829	33	8	6
Temperature	Deg. F	60	1200	1200	60	60	60	60	60	60	2350	2350	2350	60	60	60

Feed Prep System		1101 Slurry Feed	1102 TTA Recycle	1105 Dryer Screws	1106 Glass Additives	1107 Hammer Mill	1108 Pneumatic Conveyor	1109 Dry Feed Hopper	1110 Feed Transfer Screw	301 Feed to CRV Reactor	1111 Dryer Offgas	1112 Dryer Condensate	1113 Dryer Condensate Cooling Water
Mass Rate (lb/hr)	Total	59000	45100	16000	380	9780	9780	1155	1155	1535	7579	7579	253,300
	Water	53100	45100	8000	—	421	421	69	69	69	7579	7579	—
	Solids	5900	0	8000	380	9359	9359	1086	1086	1466	0	0	—
Density	lb/gal	8.72	8.33	—	—	—	—	—	—	—	—	8.33	—
	lb/ft3	—	—	76.2	90	90	90	90	90	90	0.037	62.4	—
Flow	gpm	113	90.2	—	—	—	—	—	—	—	—	15.2	506
	ft3/hr	907	725	210	4.2	104	104	12.8	12.8	17	—	121	—
	acfm	—	—	—	—	—	—	—	—	—	3385	—	—
Thermal Duty	MM Btu/hr	—	—	9.2	—	—	—	—	—	—	—	7.6	7.6
Temperature	Deg. F	60	60	60	60	250	250	60	60	60	212	180	115
Vent Air	acfm	—	12.1	10	—	10	10	10	10	10	10	10	—

Glass Product Handling System		601 Glass Product	501/502 CMS Cooling Water	602 Dragflight Steam Condensor	603 Dragflight Water Cooler
Mass Rate (lb/hr)	Total	1228	—	600	24000
	Water	—	33,665	600	—
	Solids lb/hr	1228	—	—	—
Density	lb/gal	—	—	—	—
	lb/ft3	150	—	0.037	—
Flow	gpm	—	67	—	48
	ft3/hr	8.2	—	—	—
	acfm	—	—	268	—
Thermal Duty	MM Btu/hr	—	0.84	0.6	0.6
Temperature	Deg. F	110	110	212	110
Vent Air	acfm	—	—	10	—

Air Pollution Control System		401 CMS Offgas	402 Evaporative Cooler Offgas	403 Baghouse Offgas	404 SO2 Scrubber Offgas	405 Nox Scrubber Offgas	406 ID Booster Fan Offgas
Mass Rate lb/hr	Total	3446	4946	4653	2746	2691	2691
	Solids	295	295	1.5	1.5	1.5	1.5
	O2	72.5	72.5	72.5	72.5	72.5	72.5
	N2	1854.1	1854.1	1854.1	1854.1	1854.1	1854.1
	H2O	485.2	1985.2	1985.2	105.0	53.0	53.0
	CO2	710.1	710.1	710.1	710.1	710.1	710.1
	SO2	26.7	26.7	26.7	0.11	0.11	0.11
	NOx	2.63	2.63	2.63	2.63	0.08	0.08
Temperature	Deg. F	2350	450	400	100	75	80
pressure	in. w.c.	0	-2	-6	-8	-10	5
Flow	acfm	3833	1839	1755	678	576	560
	scfm	708	1046	1046	617	546	546
Thermal Duty	MM Btu/hr	2.05	2.05	2.05	0.125	0.021	0.021

Air Pollution Control Liquid/Solid Waste Streams		503 Evaporative Cooler Water	302 Baghouse Solids Recycle	901 SO2 Scrub Cooling Water	902 SO2 Scrubber Recycle	903 SO2 & NOx Scrubber Purge	904 NOx Scrubber Recycle	905 NOx Scrubber Purge	906 20% Caustic Feed	907 Sodium Hypochlorite NaOCl	908 WWTP Purge	909 Cooling Tower Make-up
Mass Rate (lb/hr)	water	1500	—	47500	47500	1887	2600	48	139.5	—	1935	15000
	NaOH	—	—	—	—	—	—	—	34.86	—	—	—
	NaOCl	—	—	—	—	—	—	—	—	5	—	—
	Na2SO4	—	—	—	—	54.9	—	—	—	—	54.9	—
	Solids	—	295	—	—	—	—	—	—	—	—	—
Density	lb/gal	—	—	—	—	—	—	—	—	—	—	—
	lb/ft3	—	90	—	—	—	—	—	—	—	—	—
Thermal Duty	MM Btu/hr	—	—	1.9	-1.9	—	0.104	—	—	—	—	—
Temperature	Deg. F	—	250	125	100	100	75	100	60	—	75	60
Flow	gpm	3	—	95	95	3.8	20	0.10	0.28	—	3.87	30
	ft3/hr	—	2.1	—	—	—	—	—	—	—	—	—
Vent Air	(acfm)	10	—	—	—	—	—	—	—	—	10	—

Figure 6-3e. Full-scale CMS™ Process Flow (Continued)

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FOSTER WHEELER ENVIRONMENTAL CORPORATION
Vortec Corporation
FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM
PROCESS FLOW DIAGRAM SHEET 2 OF 2
E-4200-808-003

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6.8 Full-scale Plant Equipment Cost Estimate

Vortec Corporation and FWE have cooperated in deriving the project cost (equipment, start-up, and operating) with the current project arrangement; that is, Vortec will supply the CMS™ vitrification equipment and FWE will provide the balance-of-plant equipment and the construction of the facility. The following assumptions and conditions were used as a basis for cost estimating:

1. The preliminary design presented in Section 6.0 and Appendix C.
2. State and Federal Regulatory permits to be supplied by FDF.
3. Site of the plant to be provided by FDF.
4. Site support equipment to be provided by FDF.
5. Utilities to the vitrification plant to be provided by FDF.
6. Containers for the transporting the vitrified waste to be provided by FDF.
7. Plant Construction schedule is based on 40-10 work week.
8. Greater Cincinnati building & Construction Trades Counsel labor rates were used for construction labor.
9. 6.5% Ohio, Hamilton County, sales tax included with equipment, supplies, rentals, and materials.
10. No construction costs are included in accordance with FDF specification.

The Operational Cost is based on the following assumptions.

1. On site laboratory services to be supplied by FDF.
2. Environmental regulatory support to be supplied by FDF.
3. Transportation of the vitrified waste from the vitrification plant to repository to be provided by FDF.
4. Operational Health and Safety training to be provided by FDF.
5. Hazardous and Radiological training to be provided by FDF.
6. Empty cask storage to be provided by FDF.
7. Operational Staffing requirements included with Fatlac Trades.
8. Operational Staffing includes labor type and hours only. Labor rates to be established by FDF.

6.8.1 Plant Capital Cost

The estimated equipment cost for a plant to process the Silo 1 and 2 residue within 36 months of operation is approximately $8,300,000 estimated to within ± 20%.

6.8.2 Project Cost Summary

Appendix D includes detail information on the elements that compose the equipment and operating cost for this full-scale plant. Additional Equipment cost information is shown in Appendix D, Equipment Data Sheets. These data sheets include a narrative describing the function of the equipment. Operating costs include Operations Labor, Expected Equipment Lifetime, Energy Cost, and Additives Cost.

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7.0 CONCLUSIONS

7.1 VORTEC CORPORATION MET ALL CONTRACT REQUIREMENTS

Vortec conducted the Proof of Principle program for FDF completing all of the tasks and providing the deliverables as required. The principle tasks included:

1. Preparing the DS slurry to be processed during the 72 hour demonstration test.
2. Conducting the 72 hour demonstration test according to the FDF approved work plan.
3. Developing additional glass formulations for and the production of glass for two additional surrogates defined by FDF as S1 and S2.
4. Preparing a preliminary design for a full-scale plant that would process the 6,780 m^3 of residue in S1 and S2 at Fernald.

The final report summarizes the results of the test program and describes the plant design prepared by Vortec and FWE. Principle results from the test program were:

1. The CMS™ processed the required amount of DS slurry in 72 hours with the test facility operating at an overall demonstrated availability of 99.58%.
2. Samples were taken of the influent and effluent streams in accordance with the EPA's sampling protocols as defined in the FDF approved work plan. Samples were analyzed by Corning's CELS laboratory and the results are presented in this report. The data were used to establish the partitioning of the RCRA heavy metals between the glass product and the flue gas. In general, the mass balance closed within 5% around the CMS™ components with the exception of the Al_2O_3.
3. Excess Al_2O_3 appeared in the glass as a result of loss from refractory in the separator reservoir. The refractory used in the test facility is AZS based and has superior thermal shock characteristics needed for the test facility's mode of operation (thermal cycling during frequent start-ups). As with all glass manufacturing system designs, the design and selection of the refractory is a significant part of the detail design, and requires knowledge of the material being processed.
4. Measurements were made to establish the volatilization of the lead contained in the surrogate feed stream. Without recycling, the glass captured 50% of the lead. However, the glass was designed to accept 100% of the lead and, as demonstrated in the laboratory testing, actually retained the design lead loading. Recycling of the lead carry-over back into the melter, as proposed for the full scale design, will result in, greater than 90% of the lead being retained in the glass at steady-state conditions. (See Vortec's EPA SBIR Report).

7.2 PRELIMINARY DESIGN OF A FULL-SCALE SYSTEM

Vortec and FWE prepared a preliminary design for a plant that would process 6,780 m^3 of the S1 and S2 residue. As a result of the initial trade studies associated with meeting the FDF defined system constraints, the plant configuration was established to accept the slurry from the TTA and dry it to 5% moisture prior to injection into the CMS™. The drying operation will be accomplished by a duel set of centrifuges followed by heated screw type dryers. These heated screw dryers are supplied by Holo-Filite Corporation, who has provided a partial list of approximately 30 successful sludge-drying applications.

The CMS™, when designed to accept the dried silo residue, is approximately the size of the Vortec pilot operation at U-PARC. Vortec has conducted over 150 treatability type tests using dry feed injection, and has processed a wide variety of slags, ashes, glasses, dusts, and other industrial type residues.

Simplicity and reliability are the goals of the proposed full-scale feed preparation system. The centrifuges are easily cleaned and de-contaminated when maintenance is required. FWE has direct experience drying soils in heated screws as proposed here. Operation & maintenance has been addressed by means of oversizing the screws and providing redundancy (dual dryer trains). The concept is to provide a sufficiently rugged piece of equipment to operate for three years without any required maintenance. However, Vortec and FWE are proposing a validation program at the beginning of the detail design to establish the screw configuration and performance for processing the residue with various bentonite content. These tests will be conducted with non-radioactive, non-toxic materials having the rheological properties of the silo residue as received from the TTA.

The silo material was initially prepared as a finely ground uranium ore so the primary function of the grinding operation will be to reduce agglomerated material and coarse Bentogrout™ cap rubble to less than 600 microns. There is little risk that the equipment selected will not provide the performance required. Features such as reversibility and adjustability for wear would increase operating time. Other potentially lower maintenance mills could be considered such as vertical shaft impact mills or ball mills during final design.

Another operating concerns with the drying system are abrasio, dusting. The abrasive nature of the silo material will be taken into account during the design of the feed preparation de-watering, drying, storage, conveying, and feeding equipment. During the design process numerous details will be considered including materials of construction, use of wear resistant materials and linings, shaft sleeves and seals, minimization of velocities, redundancy, and maintainability in order to maximize equipment availability. As an example, the centrifuge will be lined with carbide tiles for abrasion resistance. And again, in the slurry feed areas, retainment sumps will be provided in the event of leaks. In addition, once the slurry is dry, double wall piping and other appropriate means will be included to contain material should the first line of abrasion containment fail.

All of the feed preparation components are vented and as such operate under negative pressure. Selection of all rotating equipment will consider means to prevent leakage and dusting at seals, covers, transfer points, etc. Dust-proof bearing housings, at a minimum, would be employed. On another level, purged (pressurized) seals would result in an in-leakage to the containment system should leakage occur and would be monitored to indicate seal condition.

Dust accumulation in particular vent lines will be evaluated on a case by case basis. Since all of the vent air is fed to the CMS™, many of these lines can tolerate the expected small dust loadings without concern.

Filtration of the dryer water vapor stream is a concern due to the presence, albeit small, of Bentogrout™ in the composition of the dust and the potential for fouling in the downstream condenser.

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An alternative considered is to provide for periodic wash-down of the heat exchange surface to remove any build-up of solids. All of these items will be addressed in detail design when equipment has been selected, configurations established, and estimates of depositions have been made.

The air pollution control system consists of a partial quench to 450° F followed by a bag filter and two stages of NO_x, and SO_x removal. The off gas is then sent to the RCS. Particulate removed in the bag filter is predominantly $PbSO_4$, SO_3, and SiO_2. Recycling this material into the melter will result in approximately 90% of the lead and silicon oxides entering the glass and the sulfur in the gas phase passing through the filter and is removed in the SO_x scrubber.

Vortec has conducted tests, demonstrating the effectiveness of various particulate-recycling techniques. In past testing of the WESP for lead capture, efficiencies of 99% and higher were attained. The bagfilter to be applied to the full-scale silo project would be specified to meet 99.95% removal efficiency. A bagfilter was selected for the full-scale application to allow the recycling of a dry particulate.

As with the feed preparation system, critical component testing of the recycling techniques would be conducted prior to the initiation of detail design. The Vortec facility has recently been expanded to include a bag filter in the APC system. Non-toxic, non-radioactive tank surrogates can now be processed in the test facility to establish the amount of carryover, its chemical and physical form, and to demonstrated the ability to capture lead and sulfur in the glass. Many other questions FDF has about glass properties in the molten state, could also be investigated by taking advantage of the Vortec Test Facility.

Safety concerns at the Fernald site regarding the use of an oxygen enriched CMS™ could lead Vortec to the conclusion that the full-scale design of the CMS™ should use normal air and not enriched air. If the requirement on maximum off-gas flow were relaxed and an additional carbon bed was incorporated into the RCS, the removal of the oxygen enrichment would increase off-gas volume to approximately 800 scfm and may be acceptable to FDF.

As indicated elsewhere, the loss of refractory during the POP test is not indicative of the conditions expected in the full-scale design. The test facility is subjected to thermal cycling and for that reason it has an AZS refractory in certain portions of the system. During the design of glass melting plants the selection of refractory is preceded by extensive testing of alternate refractory compositions and combinations. In general, the compatibility of the glass and refractory is a very critical design parameter that drives refractory selection. The selection of a refractory for the full-scale design will require the same through-going study and evaluation. Based on previous experience at FDF and elsewhere the initial materials selected for evaluation would include both high alumina and high chromium type refractors.

As directed by FDF, Vortec supplied cost estimates for the capital cost of the equipment and manpower requirements in a very specific and limited format.

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7.3 APPLICABILITY OF THE POP TO THE TREATMENT OF THE K-65 RESIDUE

Given that the DS is reasonably representative of the K-65 residue in S1 and S2, the POP test clearly demonstrated the effectiveness of the CMS™ technology at producing a glass that meets the specified waste acceptance criteria. The CMS™ POP 72 hour test was successfully completed 72 hours with the test facility availability of 99.58 %.

Vortec will initiate the full-scale detail design with several component tests to resolve issues of importance. However, the lack of specific components in the POP test in no way invalidates the demonstration of the technology to meet the stated objectives of making glass from the surrogate tanks residues that passes the waste acceptance criteria, and doing so with high throughput and minimum secondary waste generation.

Table 7-1 presents a comparison of the three major subsystems in the CMS™ test facility and the corresponding system in the full-scale design. The intent of the actual test was to;

1. Demonstrate the capability of the CMS™ technology to producing a glass using the slurried surrogate residue as an input,
2. Produced glass at a specified rate,
3. Operated satisfactorily for 72 hours, and
4. Produced a glass that met the waste acceptance criteria.

Using the Vortec Test Facility at the U-PARC the test was conducted and met all of the requirements. However, as expected the full-scale design had additional constraints placed on it. These constraints, after initial design studies, dictated that the feed should be dry, to reduce the off-gas flow, and that the APC should collect particulate to allow recycling of contaminants into the glass for enhanced capture.

The APC in the test facility consists of a partial quench followed by a WESP. Given the existing APC configuration, the fixed price nature contract, and the schedule modification to the system to allow for dry particulate collection were considered out of scope.

Table 7-1. Comparison of the POP Test and Full Scale Design Configurations

Component	POP Test	Full-Scale Design	Comment
Feed Preparation	Slurry Feed	Dry Feed	System configuration studies by Vortec indicated that slurry feed would result in increased CO_2 and water content in the off-gas. Dry feed reduces off-gas volume to RCS. Dry feed is that standard approach for operating the CMS™ and Vortec does not consider that such a feed configuration requires additional demonstration. Drying of the slurried surrogate will be demonstrated during the detail design. Additional funding to cover the cost of a drying demonstration was not available.
CMS	15-20 TPD size	15-20 TPD size	For the dry feed option the test facility is approximately at full-scale.
APC	Partial quench followed by a WESP	Partial quench, bag filter, two stages of scrubbing.	Test facility has a partial quench followed by a WESP. Dry APC system required by the full-scale design to obtain dry particulate for recycle of sulfur and lead. Vortec has demonstrate re-injection and would conduct further testing prior to the selection of equipment during the detail design.

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7.4 ROBUSTNESS OF THE CMS™ TECHNOLOGY

In designing a glass for a vitrification process, it is important to consider the impact of composition variations in the incoming waste stream on the final product properties and the melter operation. The glass compositions designed for meeting the TCLP requirement is considered forgiving. The primary objective after the TCLP requirement is met is to reduce the melt temperature while minimizing the additives. As illustrated during the pilot test, with a range of compositions going into the melter, the product met the present TCLP limits. If the high PbO particulate were recycled into the melter, PbO concentration in the final product would double and, in turn, potentially double the TCLP Pb leachate concentration. Even under these conditions the glass would meet the TCLP leaching requirement for lead.

The range of compositions (i.e., the system robustness) that can be processed by a Vortec type melter is bounded by the melter operating limitations and the desired glass composition. The primary melter operating constraint is a maximum temperature of 1,300°C (2,372°F)to limit the volatilization from the glass melt. The primary glass characteristics of concern are the chemical durability with regard to lead leaching and the waste loading in the glass.

For the FDF surrogate materials, the glass composition range can be illustrated by considering the desired glass composition and the surrogate composition. These compositions can be expressed on an oxide basis (with the sulfates, carbonates, and water removed) in terms of four groups. Group I: M_2O (Li_2O, Na_2O, and K_2O), Group II MO (MgO, CaO, BaO, PbO, ZnO, and NiO), Group III SiO_2, and Group IV other oxides (Al_2O_3, Fe_2O_3). The other oxides group accounts for approximately 10% of the composition by weight while the first 3 groups account for the remaining 90% of the compositions. The significant differences in the glass and surrogate compositions occur in the first three groups. To illustrate these differences, a triangle can be drawn as in Figure 7-1. The corners of the triangle represent the glass compositions: 90% SiO_2+10% other oxides, 90% MO+10% other oxides, and 90% MO_2+ 10% other oxides. (Any composition of interest is placed on this triangle by normalizing the concentrations of the first three groups to 90% and using these normalized coordinates to locate the composition on the triangle. Grid lines and concentration coordinates are marked along the axis to aid in the location of the points). Glasses with composition falling in the shaded region in Figure 7-1 have a suitable melting temperature. The data point with the lowest silica concentration is the glass from population 9, while the glasses with the highest silica concentrations are the more durable glasses designed to meet the UTS lead leach limits.

Based on the maximum PbO concentration in the surrogates, the glasses in the shaded region are expected to meet the criteria of 2.5-mg/l lead concentration in the TCLP leachate. As indicated by the diagram, a variation of 15% in the composition Group I materials, a variation of 15% in Group II of 15%, and a variation of 25% in Group III can be accommodated. In addition, it should be noted that the composition of any waste stream can be accommodated provided blending of glass making additives result in the glass having a composition in the shaded region of Figure 7-1.

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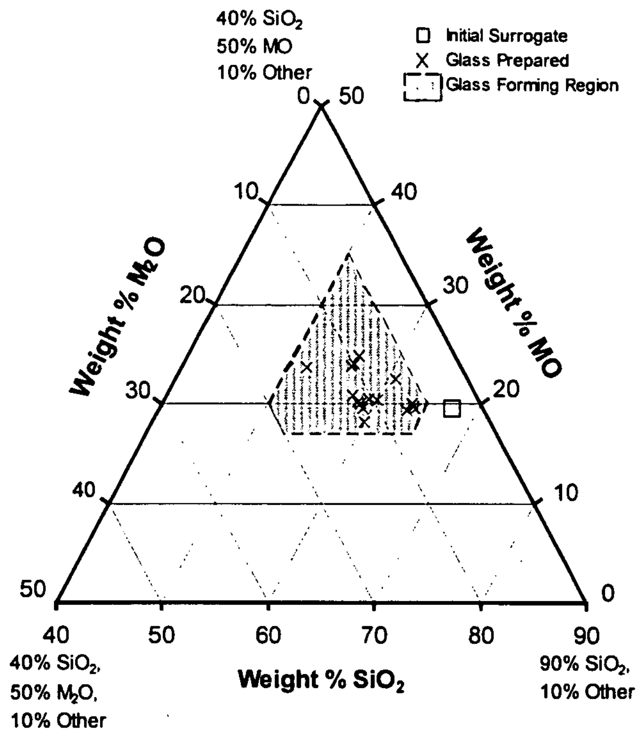

Figure 7.1. Range of Glass Compositions for Vitrification in the CMS™

It is important to note that the CMS™ technology is not adversely influenced by the physical properties of the glass melt as compared to other vitrification technologies. Electrical conductivity is not a factor in CMS™ vitrification. Since the sulfate is easily vaporized, phase separation is not a factor in melter operation. Additionally, the destruction of the sulfate phase during the melting process is not achieved through the control of the redox state of the glass melt. The viscosity of the melt does need to be controlled, but due to the small volume of glass in the melter, it can be achieved through increasing or decreasing the thermal input to the system to adjust operating temperature. The expected variations in the waste composition are not expected to have an adverse affect on melter operation.

7.5 Data Package Deliverable

All Data are available in the data package deliverable Fernald Submittal No. 40720-2241-C4-001.

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SILO 1 AND SILO 2 PROOF OF PRINCIPLE PROJECT

APPENDICES A and B

Contract No. FDF 98WO002241
Report No. BFA-4200-809-002
Fernald Submittal No. 40720-2241-C5-004

SUBMITTED TO:
Fluor Daniel Fernald
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Hamilton, OH 45013-9402

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SILO 1 AND SILO 2 PROOF OF PRINCIPLE PROJECT

APPENDIX A

List of Attendees at the 72-Hour Demonstration Test

Contract No. FDF 98WO002241
Report No. BFA-4200-809-002
Fernald Submittal No. 40720-2241-C5-004

SUBMITTED TO:
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Table A-1. List of Attendees at the 72-Hour Demonstration Test

David Jacoboski	FDF Technical Representative
Mary Morse	FDF POPT CTR Alternate
Dennis Nixon	FDF Silos Division Team Coach
Jon Smets	FDF Engineering Manager
Jeff Stone	FDF POPT Team Coach
Rod Gimpel	FDF Resident Scientist
Richard L. Maurer	FDF Silos 1 & 2 Project Manager
Nina Akgunduz	DOE Silos Project Manager
Dave Yockman	DOE
Robert Roal	Critical Analysis Team Member
Gene Jablonowsky	US EPA
Kelly Kaletsky	OH EPA
Todd Martin	Critical Analysis Team
Kevin Dietrich	FDF Process Engineer
Scott Pastor	US EPA (Subcontractor

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SILO 1 AND SILO 2 PROOF OF PRINCIPLE PROJECT

APPENDIX B

Test Report

Contract No. FDF 98WO002241
Report No. BFA-4200-809-002
Fernald Submittal No. 40720-2241-C5-004

SUBMITTED TO:
Fluor Daniel Fernald
7400 Willey Rd.
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PREPARED BY:
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72-HOUR TEST REPORT

FOR SILOS 1 AND 2
PROOF OF PRINCIPLE TESTING

Vortec Corporation's CMS™ Test Facility
University of Pittsburgh Applied Research Center
(U-PARC)

Contract: 98WO002241
Document No: BFA-4200-904-003, Revision 0

PREPARED BY:
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MARCH 1, 1999

Revision	Date	Originator	Reviewer	Approver
A	3/1/99	M. Bartone	J. Santoianni	J. Patten
0	4/14/99	M. Bartone	J. Santoianni	J. Patten

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1.0 EXECUTIVE SUMMARY

Vortec Corporation performed a 72-hour Proof of Principle Test of its Cyclone Melting System (CMS™) for the Fluor Daniel Fernald (FDF) Proof of Principle program. The objective was to demonstrate the suitability of Vortec's CMS™ technology for the treatment of silo residue at Fernald and provide energy and mass and experimental data for a preliminary design of a full-scale remediation facility. The test was performed with a pilot-scale CMS™ located in Vortec's High Temperature Process Test Facility, in Harmarville, Pennsylvania. The test employed non-radioactive surrogates that closely simulate the key chemical/physical characteristics of the actual silo residues. The test was witnessed by representatives from the U. S. Department of Energy (DOE), FDF, U. S. Environmental Protection Agency (EPA) Region 5 (Chicago), Ohio EPA, and Fernald Stakeholders group.

Approximately 8,376 kg (18,469 lb) of Demonstration Surrogate (DS) slurry, containing 30% solids, was processed over a 72.5 hour period producing about 2,676 kg (5,900 lb) of glass. Forty to sixty percent of the lead introduced into the CMS™ in the surrogate partitioned to the glass. The remainder partitioned to the flue gas. Glass samples were analyzed by an outside, FDF approved laboratory with respect to metal leachability via the U. S. EPA Toxicity Characteristic Leaching Procedure (TCLP). Results showed metals concentrations in the leachate less than one-fifth of the limits established by the Resource Conservation Recovery Act (RCRA) for toxicity in 40 CFR Part 261.24. The concentration of lead in the leachate, of particular interest to FDF, ranged from 0.42 mg/l to 0.93 mg/l, satisfying the FDF established criteria of less than 2.5 mg/l.

No problems were encountered with the CMS™ process during the test. After 52 hours of operation, a scheduled changeout and inspection of the slurry injector in the CMS™ was performed, resulting in three (3) minutes of feed interruption. On two occasions, after 66 and 68 hours of operation, the quick disconnect slurry feed hose from the slurry storage/feed tank to the pump feeding the CMS™ process plugged. The hose was disconnected and the plug rapidly cleared on both occasions resulting in feed interruptions of three minutes and five minutes, respectively. On one other occasion, an interruption of power to the slurry feed pump occurred resulting in a seven minute interruption of slurry feed to the CMS™. The cumulative interruption of slurry feed to the CMS™ during the 72.5 hours of operation was 18 minutes, resulting in a system availability of 99.59%.

2.0 INTRODUCTION

Vortec utilized its High Temperature Test Facility at Harmarville, PA to perform a 72-hour Proof of Principle Test of Vortec's Cyclone Melting System (CMS™) for the Fluor Daniel Fernald (FDF) Proof of Principle program. This report describes the test objectives, test system configuration, test procedure, data collected and analyzed, and results of data analyses.

3.0 TEST OBJECTIVES

The overall objectives of the 72-hour Proof of Principle Test were to demonstrate the suitability of Vortec's CMS™ technology for the treatment of silo residue at Fernald and provide experimental data for a preliminary design of a full-scale remediation facility. The testing employed non-radioactive surrogates that closely simulate the key chemical/physical characteristics of the actual silo residues.

Specific objectives of the test were to:

1. Process 2,600 kg (30 wt % solids) of demonstration surrogate slurry per 24-hour period for a total of 72 hours of continuous operation,
2. Obtain sufficient data to allow FDF to evaluate the potential of the CMS™ to process Silos 1 and 2 residue on a full scale basis,
3. Produce glass for subsequent analysis with respect to actual composition and leachability using both present and proposed toxicity characteristic leachability limits,
4. Evaluate feedstock injector performance with respect to FDF slurried tank waste,
5. Obtain preliminary data with respect to flue gas handling requirements through stack sampling and analysis (these data are also needed to establish partitioning),
6. Provide experimental data:
   a. For the preliminary design of a full-scale CMS™ for the treatment of Silos 1 and 2 residue,
   b. To determine best parameters to limit particulate and lead carryover into the off-gas system.
   c. To determine the best parameters for sulfate destruction and eliminate or reduce and dissolve sulfate carryover with glass.
   d. To determine the best parameters for the separation and capture of lead and sulfate in the off-gas system.
   e. To characterize secondary waste streams.

4.0 TEST SYSTEM DESCRIPTION

Figure 4-1 is a block diagram of the Vortec CMS™ test facility at the University of Pittsburgh Applied Research Center (U-PARC) in Harmarville, PA. The system has a maximum thermal input of about 5 MM Btu/hr constrained by the facility gas supply pressure. The system thus is capable of processing nominally 10-15 tons/day of dry material at 2500°F (1371°C), depending on the feedstock. Liquid additions to the feedstock will derate the system throughput as a function of the evaporation heating load, while operation at lower temperatures will reduce the solids heating load and allow increases in processing rate.

The CMS™ consists of slurry feeding and injection subsystems; an indirect-fired air preheating subsystem; a reaction and melting subsystem which includes the counter-rotating-vortex (CRV) preheater/reactor, cyclone glass melter, and glass/gas separator-reservoir; an air pollution control (APC) subsystem; a vitrified product handing subsystem; and an instrumentation and control subsystem. A flue gas instrumentation system, containing four Rosemount Analytical/Beckman analyzers, provides for on-line continuous measurement of CO, O_2, SO_2, and NO_x. In addition, the exhaust ductwork has ports to allow flue gas sampling and analysis in accordance with EPA Methods for particulate emissions, specific gases, and total hydrocarbons. The instrumentation and control system is PLC based and utilizes a PC for the graphical user interface. Data logging is provided for critical temperature, pressure, and flow measurements made in the course of a typical test run.

The test system is installed in a High Bay Area, with plan dimensions of 40' x 100', and a height of 64 ft. This area includes a tower for support of test equipment, and a 5-ton bridge crane.

Summary descriptions of each test facility subsystem are provided in the following sub-sections.

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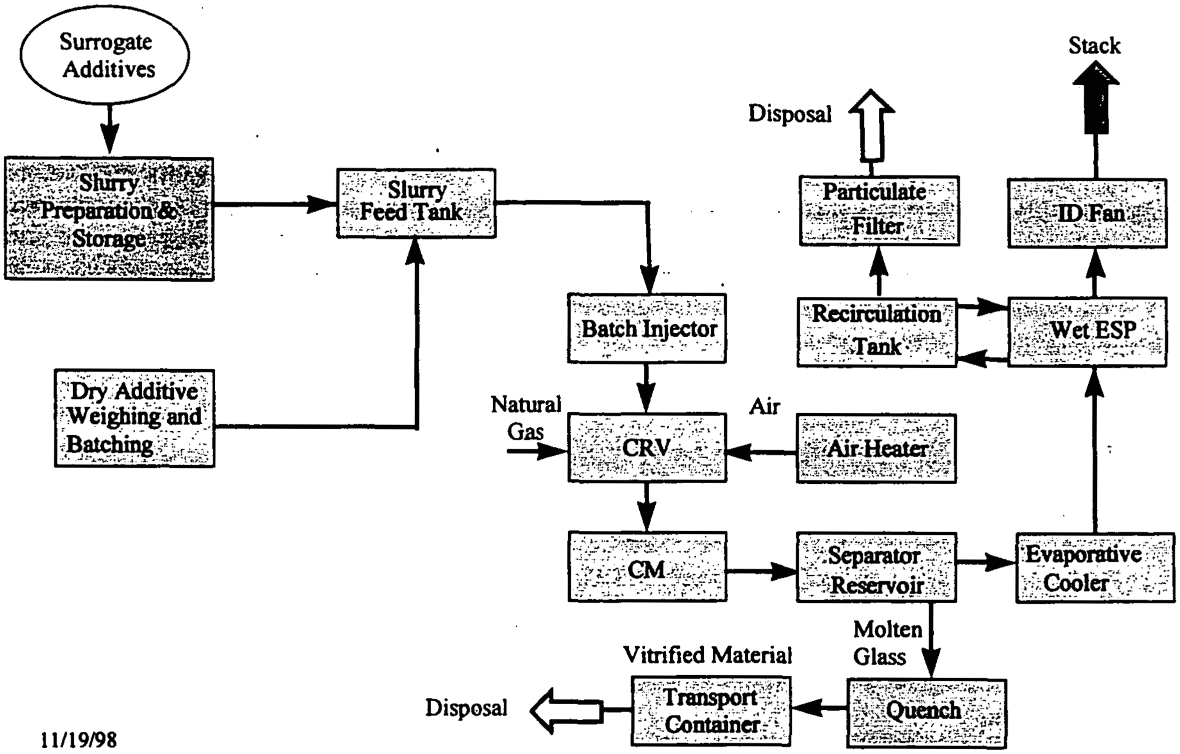

Figure 4-1. Top Level Block Diagram for the Vortec U-PARC Test Facility

4.1 DEMONSTRATION SURROGATE FEEDING AND INJECTION SUBSYSTEM

DS slurry is prepared in the slurry mixing and storage tank that is equipped with a mechanical agitator and a circulation pump to keep the slurry solids in suspension. The circulation pump is also used to transfer slurry to two feed tanks. Each feed tank contains one tenth of the total slurry (one population) required for the test. Dry glass forming additives are added to the slurry in each feed tank to form a DS feedstock (DSF). While tank "A" is delivering DSF to the CMS™, tank "B" is filled and sampled. Each feed tank is equipped with an agitator and a circulation pump to keep the solids in suspension in the slurry. A metering pump delivers DSF to the injector from the feed tanks.

4.2 REACTION AIR SUBSYSTEM

The reactor air subsystem consists of a forced draft blower and separately natural gas fired air heater. The reaction air leaves the forced draft fan and passes through the air heater where it is preheated to nominally 1000°F (538°C). Stainless steel balance valves in the inlet piping adjust the air flow at the entrance to the CRV reactor.

4.3 REACTOR AND MELTING SUBSYSTEM (CMS™)

The Vortec CMS™ consists of three major components: the CRV reactor, the cyclone melter, and the separator-reservoir. The DSF is axially injected and atomized at the top of the CRV reactor. Natural gas and pre-heated reactor air are introduced co-currently with the feed injector and tangentially into the reactor through two inlet arms in such a manner as to create two counter-rotating flow streams. As a result of the intense counter-rotating vortex mixing, it is possible to achieve reaction stability in the presence of large quantities of inert particulate matter. Both convection and radiation heat transfer mechanisms contribute to the rapid evaporation of the liquid phase and subsequent heating of the solid phase within the CRV reactor. The heated feedstock flows from the CRV reactor cyclone melter where glass reactions are completed and the product is separated from the gas stream. The separator/reservoir has a floor tap to deliver glass from the cyclone melter (alternatively, a bath of molten glass can be maintained) and routes the separated flue gas to the flue gas handling system. Descriptions of these items follow:

4.4 CRV REACTOR ASSEMBLY

The preheated reaction air and natural gas enter the CRV reactor via the lid and the inlet arms. Initial heating occurs in a pre-reactor stage between the lid and the inlet arms. At the inlet arm stage, the high inlet velocities provide a well-stirred upper section for flame stability and effective oxidation of organics and feedstock heating. The CRV reactor is a refractory lined, carbon steel, water cooled vessel. Water cooling maintains the metal surfaces of the vessel below 125°F (52°C). The vessel includes interconnecting tubing between water jacket segments and fittings for view ports, thermocouples, pilot burners, and flame safety devices.

4.5 CYCLONE MELTER ASSEMBLY

Hot gases and preheated solid materials exit the CRV reactor and enter the cyclone melter where the glass melting is completed. The cyclone melter is a horizontal cylinder with a vertical tangential entrance at one end and a horizontal tangential exit at the floor of the melter at the other end. Gas dynamics within the melter separate the glass from the gas products. The glass flows through the cyclone melter in a thin layer, principally along the floor of the horizontal cylinder. The gas and the glass exit together though the tangential exit with the glass remaining on the floor and continuing on into the separator/reservoir. The melter is a refractory lined, carbon steel, water cooled vessel. Water cooling maintains the metal surfaces of the vessel below 125°F (52°C).

4.6 SEPARATOR/RESERVOIR

The separator/reservoir is a refractory lined chamber that completes the separation of the glass from the reaction products and provides the ability to maintain a pool of glass if required for dissolution or homogeneity. The glass exits the cyclone melter into a channel in the separator/reservoir. A weir was constructed at the end of the channel for the proof of principle test to build up a pool of glass, thus providing for a glass residence time of about an hour. Glass flowing over the weir forms a cylindrical stream and drops through a tap hole in the floor of the channel. The hot gases are directed from the separation chamber to the evaporative cooler interfacing ductwork.

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4.7 FLUE GAS TREATMENT SYSTEM

The flue gas is conditioned by an evaporative cooler to reduce the temperature to nominally 450°F (232°C) to allow for flue gas sampling and ease of handling to the Wet Electrostatic Precipitator (WESP). The flue gas from the separator/reservoir is directed to the evaporative cooler via a refractory lined steel duct. In the evaporative cooler, air-atomized water is sprayed into the flue gas at the top of the cooler. The evaporation of the water cools the flue gas to the design temperature. The flue gas discharges from the bottom of the evaporative cooler into stainless steel ductwork leading to the WESP.

The primary stage of the WESP is a rod deck venturi scrubber that removes large particulates and saturates the flue gas prior to entering the WESP. Final particulate removal occurs in the WESP. The WESP water is recirculated through storage tanks where make-up water is added and the pH is adjusted in the range of 5 to 8. Emission testing is performed to characterize the uncontrolled emissions upstream of the WESP in support of the design of an appropriate commercial flue gas handling system. At the conclusion of a test, the WESP water is run through a filter press to remove the solids. The solids and the liquid are disposed of as required.

5.0 DATA COLLECTION

Figure 5-1 is a process flow diagram for the Vortec pilot plant that shows the sampling locations for the process. The control volume for the Vortec process is drawn around the following CMS™ components: CRV reactor, cyclone melter, separator/reservoir, and evaporative cooler. The inputs to this system include the surrogate slurry to be treated, the dry additives required to produce the design glass composition, fuel (natural gas in this case), reaction air, feedstock atomization air, and water and atomizing air for flue gas cooling. Outputs from this control volume are glass product and the flue gas.

5.1 DATA MEASUREMENTS

The mass flow rates of all of the inputs were measured along with their associated temperatures and pressures as well as reactor and melter temperatures. Additionally, continuous measurement of CO, O_2, SO_2, and NO_x in the flue gas were performed. The parameters monitored are identified in Table 5-1.

The air, natural gas, and evaporative cooler water flowrates; pressures; temperatures; and flue gas composition were automatically logged into the computer based data acquisition system at 1 minute intervals. These data were later reduced to five minute averages. The flowrate of cooling water to system components, measured by rotometers, are manually recorded on data log sheets at the beginning of each population period.

The flowrate of feedstock to the CMS™ was calculated by measuring the drop in feedstock level in the feed tank over a 30 minute period of time. These data were measured at 30 minute intervals throughout the test and were manually recorded in a feedstock flowrate log.

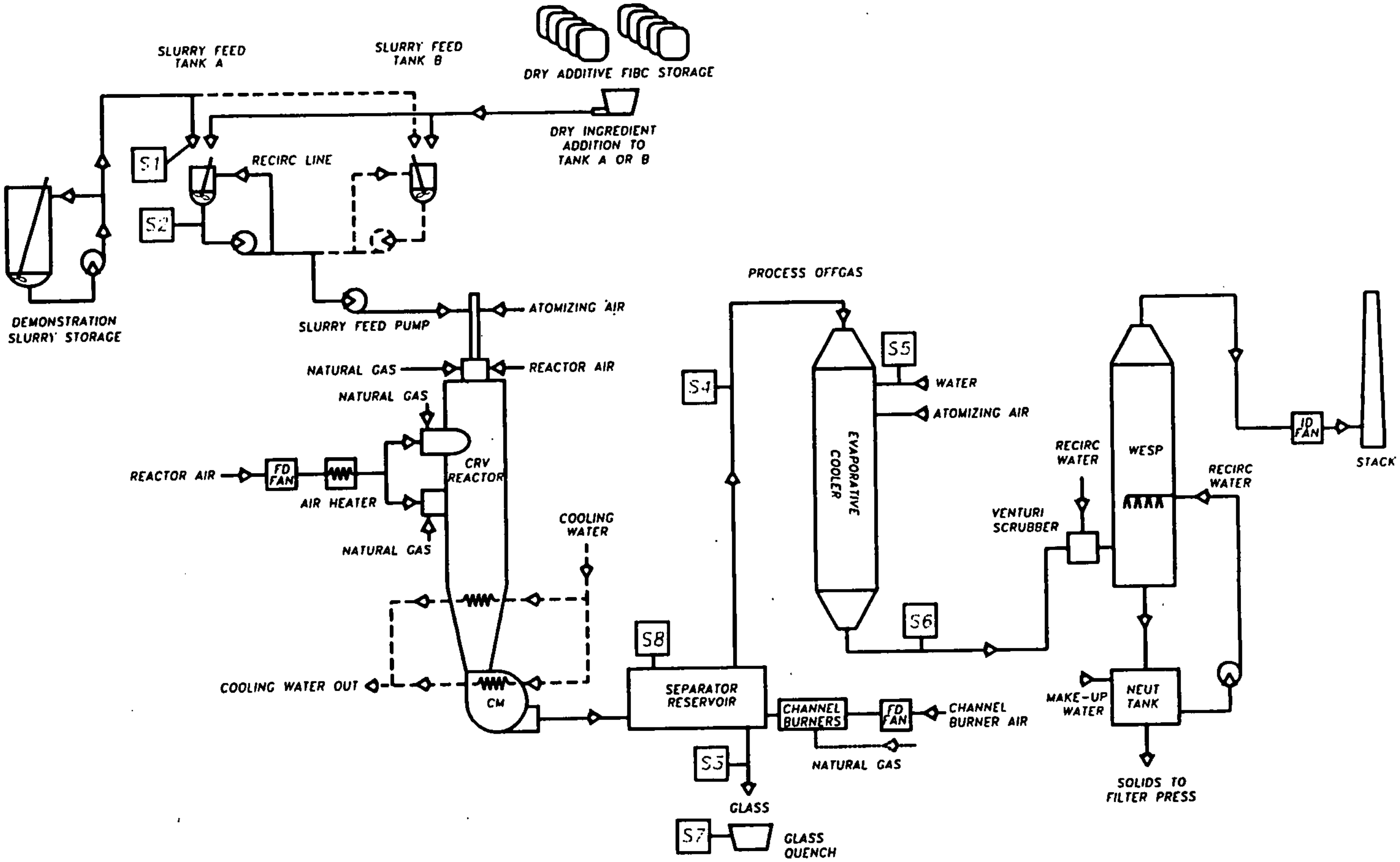

Figure 5-1. Vortec Pilot System Schematic

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Table 5-1. Data Monitored

Flow Rates	Temperatures
1. Total air to CRV reactor	1. CRV reactor gas
2. Total gas to CRV reactor	2. Cyclone melter (CM) gas
3. Air to Emhart burners	3. Separator-Reservoir (S/R) gas
4. Natural gas to Emhart burners	4. Glass at CM discharge
5. DSF to CRV reactor	5. Cooling water inlet
6. DSF atomization air	6. Cooling water discharge
7. Water to evaporative cooler	7. Gas from S/R to evaporative cooler
8. Air to evaporative cooler	8. Gas at evaporative cooler discharge
9. Cooling water to components	
	Flue Gas Composition
Pressures	1. O_2
1. CRV reacotor	2. CO
2. S/R	3. SO_2
	4. NO_x

5.2 SAMPLING POINTS AND FREQUENCY

Figure 5-1 includes the sampling point numerical designators. The sampling locations are the process inlet and exit points for the flow streams that require chemical analysis. The analysis of the feedstock is the starting point for verification of the feedstock composition and quantification of contaminants. The partitioning of the elements of interest among the various outlet streams is determined through chemical analysis of the outlet stream samples and the mass flows measured during the test sampling period.

The influent and effluent streams sampled and the frequency of sampling are presented in Table 5-2. Vortec (or its subcontractor, Horizon) supplied pre-labeled sample containers (glass and polypropylene) and necessary preservatives. The Vortec QA Manager instructed all test personnel on the sampling procedures to be followed. The Vortec Laboratory Coordinator verified that all of the sampling containers needed for shipping the samples to the analytical laboratory were available prior to test initiation. Ice packs and coolers were provided for samples requiring refrigeration for preservation.

5.3 SAMPLING METHODOLOGY

5.3.2 Demonstration Surrogate (DS) Slurry

The DS slurry was prepared in a nominal 2,000 gallon capacity mix tank approximately three weeks prior to initiation of the 72-hour test. Quantities sufficient for each sample population (1/10 of total slurry) were pumped into one of two 200 gallon feed tanks during the test at the beginning of the previous population period. For example, when feed for population period #2 was initiated, slurry for population period #3 was transferred from the 2,000 gallon capacity mix tank to the empty 200 gallon feed tank. A slurry sample was obtained from the slurry population as it entered the 200 gallon tank.

Table 5-2. System Performance Sampling Matrix

Sampled Material	Sampling Frequency	# of Samples per population	Sampling Point
DS Slurry (no additives)	Once per population	1	S1
DSF (contains additives)	Once per population	1	S2
Glass Patty	Once every hour	6	S3
Glass Frit	Once per population	1	S3
Cullet Quench Water	Once per population	1	S7
Evaporative Cooler Water	Once per population	1	S5
Flue Gas Particulate	Once per population	1	S6
Flue Gas Composition	Continuous	Continuous	S4
Sample from Separator Res.	Once at end of test	NA	703

A one-third liter sample was taken at the start of tank filling, a one-third liter sample at the filling mid-point, and a one-third liter sample at the end of the filling period. These samples were composited into a single 1 liter sample. The sampling point is designated S1 in Table 5-2.

5.3.3 Demonstration Surrogate Feedstock (DSF)

Dry glass forming additives were mixed with the DS slurry in each 200 gallon feed tank after the DS slurry had been transferred to the 200 gallon feed tank and sampled. The DSF was blended in the feed tank via the agitator and recirculated for a period of about six hours. A sample of the DSF was then taken at the end of the six hour period. The DSF sample was taken from the recirculation line (sample designation S2).

5.3.4 Glass Patty and Frit Samples

There are no formal ASTM procedures for sampling the treated surrogate (glass), so the following methodology was utilized to standardize the process. The glass patty samples were obtained from the stream of molten glass at sampling site S3 by Vortec personnel. Each patty was formed by using a steel ladle to catch the glass stream for one minute. The ladle was cooled in water by immersion and rinsed with distilled water between samples to reduce the chance of contamination. The samples were placed in stainless steel containers to air cool and allowed to fracture. After drying, Horizon personnel placed the samples in air tight containers and labeled the containers as per the chain of custody format. Six glass patty samples were taken for each of the ten populations being processed, one every hour beginning one hour after the start of the population period.

Glass frit samples were collected once per population period by Vortec personnel by placing a slotted scoop in the glass quench water below the molten glass stream. After glass frit had been collected, the scoop was removed, the water drained, and the sample placed in a perforated container and allowed to dry. A total of five liters of frit were sampled in this manner for each population period. The samples were then placed in containers by Horizon personnel who labeled the containers in accordance with the chain of custody procedures.

Table 5-3 designates the sampling schedule. FDF randomly chose Batches 2, 5, and 9 to provide glass samples for analysis. **2295**

Table 5-3. Glass Sampling Schedule

Population	No. Samples	Sample Size	Analysis	Destination	Total Samples per Population
Glass Patties					
All Populations	1	1 patty	Archive	Vortec	6
Frit					
All Populations	1	1 liter	Archive	FDF	1
	1	3 liters	Archive Final	FDF	1
	1	1 liter	Archive	Vortec	1

5.3.5 Evaporative Cooler Water

One composite evaporative cooler water sample was obtained by Horizon personnel from the municipal water input to the cooler system at Sampling Site S5. The purpose of collecting the sample is to determine if there is any metal contamination in the water that would increase the concentrations in the flue gas particulate. The water sample was analyzed for Si, Al, Ca, Mg, Na, K, Fe, Li, Ba, Zn, Ni, Pb, Cr, V, P, As, Se, and total solids.

5.3.6 Flue Gas Particulate

The quantity of flue gas particulate was sampled by EPA Method 5 as described in 40 CFR, Part 60 by Comprehensive Safety Compliance, Inc. (CSC) at sampling site S6, Figure 5-1. A bulk flue gas particulate sample was also collected for chemical analysis. CSC was responsible for obtaining this material in accordance with the regulations. They then transferred the samples to Horizon personnel who placed them in containers labeled in accordance with the chain of custody procedures. The particulate samples which correspond with the three random glass sampling events were sent out for chemical analysis.

5.3.7 Flue Gas Composition

A Vortec managed flue gas instrumentation system, containing four Rosemount Analytical/Beckman analyzers, provided for on-line continuous measurement of CO, O_2, SO_2, and NO_x at sampling site S4. CSC also sampled the flue gas for SO_2 at sample site S6.

5.3.8 Secondary Wastes

The small quantities of secondary wastes produced during the 72-hour test, primarily filter cake from the WESP, will be analyzed for hazardous characteristics and then disposed of accordingly.

5.3.9 Separator/Reservoir Sample

A sample of the glass coating on the refractory in the bottom of the separator/reservoir was taken at the end of the 72-hour test. The sample was visually inspected for evidence of metallic lead buildup in the bottom of the separator/reservoir.

5.4 VIDEO TAPING

A video recording was made of key procedures during the proof of principle test. Taped procedures and the minimum frequency/duration of taping are identified in Table 5-4. A log of the recorded tapes is provided in Table 5-5.

In addition to the continuous taping of the glass stream from the separator/reservoir, the control room, the area around the CRV reactor, and the slurry feed tanks were continuously taped. The video signals were also sent to two monitors in a visitors room continuously during the test. The monitors were equipped with signal switching devices that allowed viewers to select any one of the three areas continuously video recorded.

Table 5-4. Video Recording Matrix

Procedure/Event	Frequency	Duration
System Equipment	Once	N/A
DS Feedstock Preparation	Once	Entire Procedure
DS Feedstock Sampling	Once	Entire Procedure
Glass Sampling	Once	Entire Procedure
Evap. Cooler Water Sampling	Once	Entire Procedure
Cullet Water Sampling	Once	Entire Procedure
Flue Gas Particulate Sampling	Once	Continuous
Glass Stream from CMS™	Continuous	72-hours
CRV Reaction Zone	One Time	N/A
Cyclone Melter Reaction Zone	One Time	N/A

Table 5-5. Video Recording Matrix

Date	Camera Location-Tape No.	Tape Format	Start Time	Stop Time	Comments
12/1/98	Control Room-0	VHS	10:26 a.m.	4:26 p.m.	Feedstock initiated at 10:35 a.m.
12/1/98	Control Room-1	VHS	4:26 p.m.	10:30 p.m.	
12/1/98	Control Room-2	VHS	10:30 p.m.	4:35 a.m.	
12/2/98	Control Room-3	VHS	4:35 a.m.	10:35 a.m.	
12/2/98	Control Room-4	VHS	10:35 a.m.	4:35 p.m.	
12/2/98	Control Room-5	VHS	4:35 p.m.	10:35 a.m.	
12/2/98	Control Room-6	VHS	10:35 p.m.	4:45 a.m.	
12/3/98	Control Room-7	VHS	4:45 a.m.	10:45 a.m.	
12/3/98	Control Room-8	VHS	10:45 a.m.	4:45 p.m.	
12/3/98	Control Room-9	VHS	4:45 p.m.	10:25 a.m.	
12/3/98	Control Room-10	VHS	10:25 p.m.	4:35 a.m.	
12/4/98	Control Room-11	VHS	4:35 a.m.	11:15.a.m.	8 hour tape
		VHS			
12/1/98	Glass Stream-0	VHS	10:25 a.m.	4:27 p.m.	Intermittent glass flow began at 11:27 a.m. Full glass flow began at 12:33 p.m.
12/1/98	Glass Stream-1	VHS	4:27 p.m.	10:30 p.m.	10:25 p.m. Vortec taking glass samples. Horizon taking quench water samples.
12/1/98	Glass Stream-2	VHS	10:30 p.m.	4:35 a.m.	
12/2/98	Glass Stream-3	VHS	4:35 a.m.	6:35 a.m.	
12/2/98	Glass Stream-4	VHS	6:35 a.m.	8:35 a.m.	
12/2/98	Glass Stream-5	VHS	8:35 a.m.	10:30 a.m.	
12/2/98	Glass Stream-6	VHS	10:30 a.m.	12:30 p.m.	
12/2/98	Glass Stream-7	VHS	12:30 p.m.	2:30 p.m.	Roll up bay door was opened causing air to shift glass stream. This caused camera focus problems and bright backlighting.
12/2/98	Glass Stream-8	VHS	2:30 p.m.	4:30 p.m.	
12/2/98	Glass Stream-9	VHS	4:30 p.m.	6:30 p.m.	

Table 5-5. Video Recording Matrix (Continued)

Date	Camera Location-Tape No.	Tape Format	Start Time	Stop Time	Comments
12/2/98	Glass Stream-11	VHS	8:35 p.m.	10:35 p.m.	9:00 p.m. work on glass stream exit "drain hole" to improve the stream (see also tape 8mm-4).
12/2/98	8mm-3	8mm	10:20 p.m.	12:20 a.m.	Work on the glass exit "drain hole" to improve stream.
12/2/98	Glass Stream-12	VHS	10:35 p.m.	12:45 a.m.	15 minutes lost during tape change.
12/3/98	Glass Stream -13	VHS	1:00 a.m.	3:05 a.m.	
12/3/98	Glass Stream -14	VHS	3:05 a.m.	5:00 a.m.	
12/3/98	Glass Stream -15	VHS	5:00 a.m.	7:00 a.m.	
12/3/98	Glass Stream -16	VHS	7:00 a.m.	9:00 a.m.	
12/3/98	Glass Stream -17	VHS	9:00 a.m.	11:00 a.m.	
12/3/98	Glass Stream -18	VHS	11:00 a.m.	1:00 p.m.	
12/3/98	Glass Stream -19	VHS	1:00 p.m.	3:00 p.m.	
12/3/98	Glass Stream -20	VHS	4:15 p.m.	6:15 p.m.	Tape was not started on time.
12/3/98	Glass Stream -21	VHS	6:15 p.m.	8:25 p.m.	
12/3/98	Glass Stream -22	VHS	8:25 p.m.	10:25 p.m.	
12/3/98	Glass Stream -23	VHS	10:25 p.m.	12:25 a.m.	
12/4/98	Glass Stream -24	VHS	12:25 a.m.	2:25 a.m.	
12/4/98	Glass Stream -25	VHS	2:25 a.m.	4:30 a.m.	
12/4/98	Glass Stream -26	VHS	4:30 a.m.	6:35 a.m.	
12/4/98	Glass Stream -27	VHS	6:35 a.m.	8:35 a.m.	
12/4/98	Glass Stream -28	VHS	8:35 a.m.	10:30 a.m.	
12/4/98	Glass Stream -29	VHS	10:30 a.m.	12:00 p.m.	Test End
12/1/98	CRV Lid-0	VHS	10:25 a.m.	4:27 p.m.	
12/1/98	CRV Lid -1	VHS	4:27 p.m.	10:30 p.m.	Population #2 started at 5:15 p.m.
12/1/98	CRV Lid -2	VHS	10:30 p.m.	1:40 a.m.	VHS recording deck failed at 1:40 a.m. Back up 8mm deck recorded video until VHS deck was restored.

Table 5-5. Video Recording Matrix (Continued)

Date	Camera Location-Tape No.	Tape Format	Start Time	Stop Time	Comments
12/1/98	8mm-1	8mm	10:35 p.m.	12:46 a.m.	
12/2/98	8mm-2	8mm	12:46 a.m.	2:55 a.m.	At 1:34 a.m., MKM of FDF switched the video feed to the "upper level" camera to view the cleanup of the slurry spill that occurred. At 1:48 a.m. MKM switched the video feed to the glass stream. Video feed was restored to CRV lid at 2:17 a.m.
12/2/98	CRV Lid -3	VHS	4:35 a.m.	10:35 a.m.	VHS deck restored at 4:35 a.m. Population #4 started at 8:15 a.m. Population #5 was batched and mixed at 9:15 a.m.
12/2/98	CRV Lid -4	VHS	10:35 a.m.	4:35 p.m.	
12/2/98	CRV Lid -5	VHS	4:35 p.m.	10:35 p.m.	At 8:05 p.m. CSC began a flue gas sample.
12/2/98	CRV Lid -6	VHS	10:35 p.m.	4:45 a.m.	Population #6 started at 11:35 p.m. At 1:30 p.m. repair to Feed Tank A piping.
12/3/98	CRV Lid -7	VHS	4:45 a.m.	10:50 a.m.	At 5:00 a.m., increased feed throughput. At 6:55 a.m. started feeding Population #7. At 8:30 a.m. batched Population #8.
12/3/98	CRV Lid -8	VHS	10:50 a.m.	4:50 p.m.	At 9:08 p.m. began feeding Population #9. At 9:50 p.m. batched Population #10.
12/3/98	CRV Lid -9	VHS	4:50 p.m.	10:25 p.m.	
12/3/98	CRV Lid -10	VHS	10:25 p.m.	4:35 a.m.	At 4:30 a.m. began feeding Population #10.
12/4/98	CRV Lid -11	VHS	4:35 a.m.	11:15 a.m.	Test End
12/4/98	8mm-4	8mm			Compilation of vidéo recorded on the DV format

6.0 TEST PERSONNEL TRAINING

Prior to the initiation of the Proof of Principle Test, Vortec personnel who would be involved in the test attended a training seminar conducted by the test engineers, the QA Manager, and the Test Data Manager. The seminar described the responsibilities and activities of personnel involved in slurry and feedstock preparation, feeding, and sampling; emissions control system operation; system control operation; and glass sampling. All personnel were provided with copies of the test plan and test procedures. Personnel were also instructed in test and facility safety procedures.

On the day prior to the beginning of the Proof of Principle Test, all test personnel received on-site training in the particular tasks for which they were responsible.

7.0 TEST DESCRIPTION

7.1 DEMONSTRATION SURROGATE SLURRY PREPARATION

Vortec began preparation of the DS slurry on September 23, 1998, and completed the preparation on November 30, 1998. Approximately 8,376 kg (18,469 lbs) of slurry was prepared consisting of the ingredients presented in Table 7-1.

DS slurry preparation was initiated by introducing about 90% of the deionized water (11,600 lbs) into the 2,000 gallon slurry storage tank. The volume of water to be introduced into the tank was first calculated. Then the desired level of the water in the tank was calculated based on the tank dimensions, and a level marked on the inside wall of the tank. A deionizer was installed in the water supply line, and water was then introduced into the tank until it reached the marked level. The agitator in the tank was then turned on prior to introduction of the other slurry ingredients.

The BentoGrout [Ingredient #21] was the first solid material introduced into the water in the slurry storage tank on September 23. It was slowly added and slaked onto the surface to avoid large clumps dropping into the water. After all the BentoGrout was added, one barrel of magnesium phosphate ($Mg_2(PO_4)_3$) [#5], sixty-two percent of the total $Mg_2(PO_4)_3$ that was to be in the surrogate, was added to the mixture. It was near the end of the working day, so addition of the remainder of the $Mg_2(PO_4)_3$ was scheduled for the following day, September 24. The mixture was agitated overnight to ensure that the BentoGrout clumps were completely broken up and the dry chemicals were completely hydrated.

On September 24, prior to continuation of the surrogate preparation, FDF informed Vortec that the lead (Pb) concentration in the leachate from leach testing on the validation surrogate, previously prepared in Vortec's laboratory, was lower than their criteria. FDF then instructed Vortec to postpone completion of the preparation of the surrogate for the 72-hour test pending further evaluation.

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Table 7-1. Demonstration Surrogate Slurry Composition

Ingredient No.	Ingredient	Weight lb	Weight kg	Wt. Pct.
1	Na_4HAsO_4	14.54	6.59	0.079
2	$BaSO_4$	417.51	189.30	2.26
3	Na_2CrO_4	13.82	6.27	0.075
4	Fe_2O_3	128.93	58.50	0.698
5	$Mg_2(PO_4)_3$	96.80	43.90	0.524
6	$NaNO_3$	52.58	23.80	0.285
7	NiO	21.94	9.95	0.119
8	PbO	289.26	131.20	1.57
9	$PbCO_3$	336.87	152.80	1.82
10	$PbSO_4$	135.41	61.40	0.733
11	Na_2SeO_3	7.75	3.51	0.042
12	Coarse SiO_2	1,061.57	481.40	5.75
13	Fine SiO_2	964.38	437.40	5.22
14	Fumed SiO_2	467.60	212.10	2.53
15	V_2O_5	4.60	2.09	0.025
16	ZnO	0.51	0.231	0.003
17	Tributyl Phosphate	46.92	21.28	0.254
18	Kerosene	46.92	21.28	0.254
19	Diatomaceous Earth	93.34	42.33	0.505
20	Feldspar	934.80	423.90	5.06
21	BentoGrout	475.30	215.60	2.57
22	Deionized Water	12,858.00	5,831.00	69.60
Total		18,469.40	8,375.80	100.00

Preparation of the 72-hour test surrogate recommenced on November 9, 1998, with FDF representatives witnessing the preparation. By this time, FDF had concluded that the low Pb leach rate from the validation surrogate was due to the addition of $Mg_2(PO_4)_3$. Therefore, the decision was made to continue preparation of the 72-hour test surrogate by adding all the remaining ingredients except for the additional $Mg_2(PO_4)_3$. The surrogate would then be sampled and analyzed by FDF, and FDF would then decide what modifications, if any, would be made to the surrogate composition.

The water soluble compounds [#1, #3, #6, #11] were weighed out and added to the mixture in the 2,000 gallon tank. This was followed by the addition of a mixture of the fine silica [#13] and organics [#17, #18]. The fine silica and organics were first mixed together by adding about 1/5 of each ingredient into five 55 gallon drums and rotating the drums for 15 minutes on a motorized drum rotator. The contents of the drums were then added to the mixture in the slurry tank.

Following the addition of the fine silica and organics, powdered lead sulfate ($PbSO_4$) [#10] was delumped and added to the slurry. The delumping was accomplished by putting the $PbSO_4$, 3/8" steel mixing balls, and deionized water in a Nalgene container, placing a cover on the container, and rotating the container on the drum rotator for one hour. The contents of the container were then sifted through a 50 mesh screen to remove unground particles and the mixing balls. The unground particles and mixing balls were then returned to the container and again rotated. This procedure was repeated until all of the particles passed through the 50 mesh screen. The delumped material was then added to the slurry tank.

The remaining dry ingredients [#2, #4, #7, #8, #9, #12, #14, #15, #16, #19, #20, #21] were then added to the slurry tank. Only 1,016 lbs of coarse silica was added at this time, the design amount if all the ($Mg_2(PO_4)_3$) would be used.

The slurry mixture in the tank was then sampled (about 100 grams) and placed in a tared crucible. The filled crucible was weighed and placed in an electric furnace. The furnace was heated to 200°F (93°C) and maintained at that temperature until the slurry dried. The crucible was then removed from the furnace and weighed. The moisture content of the slurry was then calculated based on the difference in weight before and after drying. The amount of water that must be added to the slurry to achieve 70% water in the slurry was then calculated. The increase in the level of the slurry in the tank that would result in the addition of the water was calculated based on the tank dimensions, and a mark made at that level on the inside surface of the tank. Deionized water was then added to the slurry tank until that level was achieved.

After completion of the DS slurry preparation (except for the additional ($Mg_2(PO_4)_3$) on November 12, a 1 liter sample of the slurry was taken from the recirculation line by Horizon and sent to FDF for leachability analysis. Based on the leachability data, FDF decided not to add any additional $Mg_2(PO_4)_3$, but to replace the additional $Mg_2(PO_4)_3$ with coarse silica, bringing the total quantity of coarse silica in the slurry to that shown in Table 7-1. The additional silica was added on November 30, 1998, the day before the beginning of the proof of principle test.

Immediately before the beginning of the proof of principle test, additional samples of the slurry were taken from the recirculation line. The moisture content of the DS slurry was again measured by Vortec and found to be 70% (FDF independent analysis indicated a 71% moisture content).

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7.2 GLASS ADDITIVES PREPARATION

On November 30, 1998, the dry glass additives were mixed in preparation for the proof of principle test. The ingredients were split into ten batches, one for each population, each having the quantities shown in Table 7-2, and placed in separate flexible intermediate bulk containers (supersacks). The quantity of additives was established for each population based on the processing of 2,000 lbs of DSF per population with 90% DS slurry and 10% glass additives. Each supersack was marked with a corresponding population number from 1 to 10.

Table 7-2. Quantity of Glass Additives Prepared Per Population

Ingredient	Lbs per Supersack	Kg per Supersack
Li_2CO_3 (Lithium Carbonate)	55.0	24.94
Na_2CO_3 (Soda Ash)	55.0	24.94
$CaCO_3$ (Limestone)	90.0	40.82
Total	200.0	90.70

7.3 TEST OPERATION

7.3.1 Summary

Heat-up of the CMS™ for the Proof of Principle Test was initiated on November 29, 1998. DSF feed to the CMS™ was initiated at 10:32 a.m. on December 1, 1998, and was maintained until 11:09 a.m. on December 4, 1998, for a total operational duration of about 72.5 hours. All of the DS slurry prepared, about 8,376 kg (18,469 lbs), was processed resulting in an average throughput of 2,770 kg/day. At the end of the test, the 2,000 gallon DS slurry storage tank and the two 200 gallon DSF feed tanks were washed out. The water used to clean the tanks was collected and added to the slurry and became part of the last population that was processed in the CMS™. The total quantity of DSF processed, including the additional cleanup water added to the last population, was approximately 9,570 kg (21,104 lb).

No problems with the CMS™ process were encountered during the test. The cumulative duration of DSF feed interruptions during the test was 18 minutes — three minutes for a scheduled injector changeout and inspection, a seven minute power interruption to the DSF feed pump, and eight minutes due to slurry feed line blockages. The resulting system availability was 99.59%.

A schedule identifying the date and time at which each of the ten populations started and ended during the 72-hour test is presented in Table 7-3. Plots of the DSF, natural gas, and reaction air flow rates to the system and cyclone melter exit gas temperature versus time over the 72-hour test are presented in Figure 7-1. The running test average DSF flow rate and cumulative DSF flowrate versus time over the duration of the test are presented in Figure 7-2. The following sections provide detail discussions of the test operation, data analysis, and results and conclusions.

Table 7-3. Proof of Principle Test Schedule

Population No.	Date	Population Start Time	Actual Test Duration	Scheduled Test Duration
1	12/1/98	10:32 a.m.	0	0
2	12/1/98	5:20 p.m.	6.8	7.2
3	12/2/98	12:13 a.m.	13.68	14.4
4	12/2/98	8:16 a.m.	21.73	21.6
5	12/2/98	4:05 p.m.	29.55	28.8
6	12/2/98	11:45 p.m.	37.22	36.0
7	12/3/98	6:55 a.m.	44.39	43.2
8	12/3/98	1:25 p.m.	50.89	50.4
9	12/3/98	9:09 p.m.	58.62	57.6
10	12/4/98	4:40 a.m.	66.14	64.8
End of Test	12/4/98	11:04 a.m.	72.54	72.0

7.3.2 Operation Details

On the evening of November 30, DS slurry for the first population (1,800 lbs) was transferred from the 2,000 gallon DS slurry storage tank to one of the two 200 gallon DSF feed tanks. Prior to transfer of the DS slurry, a mark was made on the inside surface of the 200 gallon feed tank to indicate the level to which the DS slurry should be filled for each population. This level was determined by calculating the volume of DS slurry for one population and, based on the physical dimensions of the tank, calculating the height to which the DS slurry should reach in the tank. After transfer of the DS slurry for the first population to the feed tank, the contents of one supersack of glass additives were loaded into a dry additive feed tank and then transferred via a screw feeder into the DSF feed tank. The solids in the DSF feed tank were maintained in suspension by an agitator in the tank and by continuously recirculating DSF from the bottom of the tank. The DS slurry transfer and glass additive mixing procedures were repeated for the second population in the other DSF feed tank and subsequently for each population throughout the test. Samples of the DS slurry were taken during the transfer as defined in Section 5.3.1. The DS slurry transfer and DSF preparation for populations 1 and 2 were performed by the Vortec personnel who performed this function throughout the test. They were supervised by the test engineers, QA Manager, and Slurry Preparation Manager.

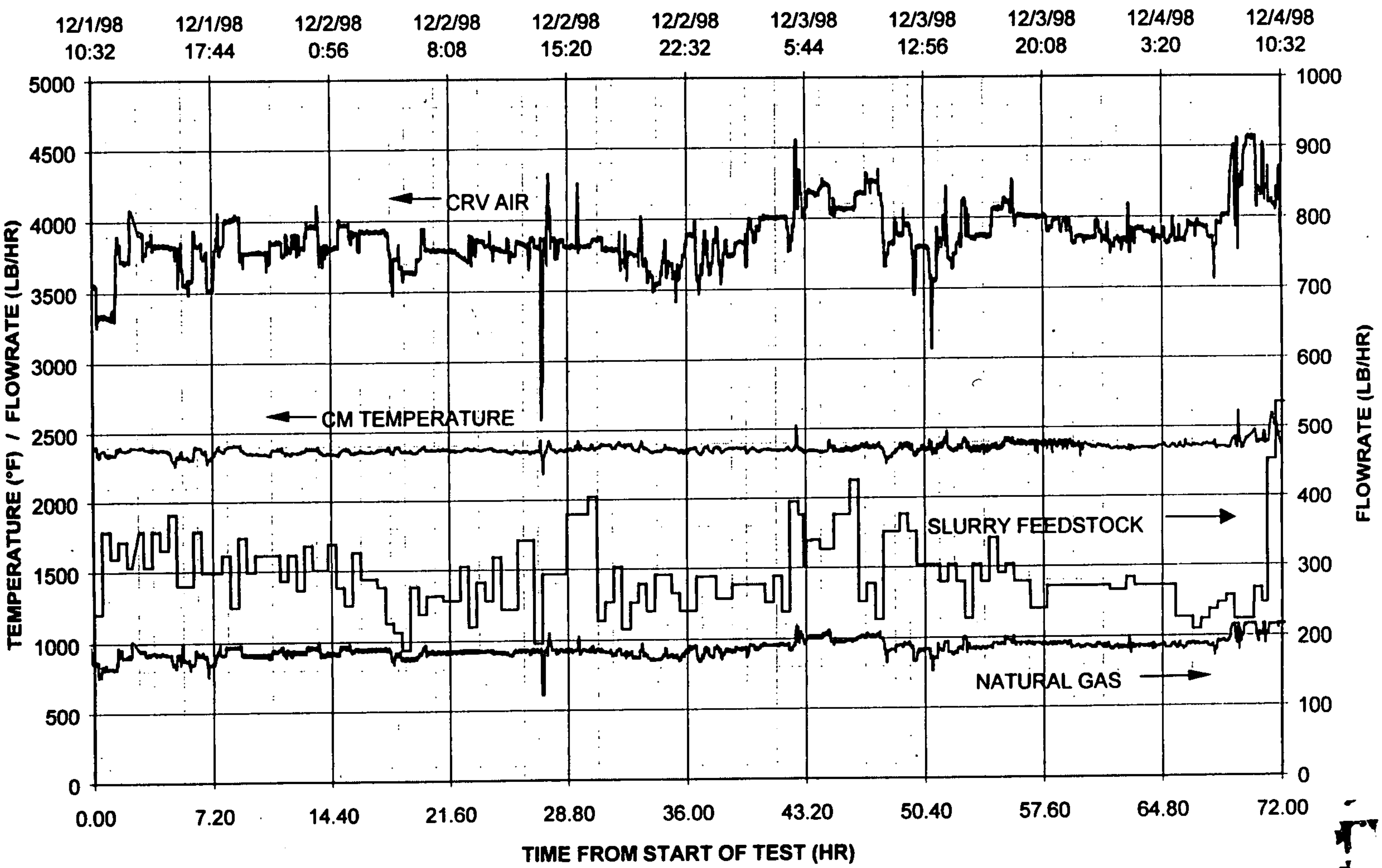

Figure 7-1. Flowrates and Process Temperature Versus Time Over Proof of Principle Test

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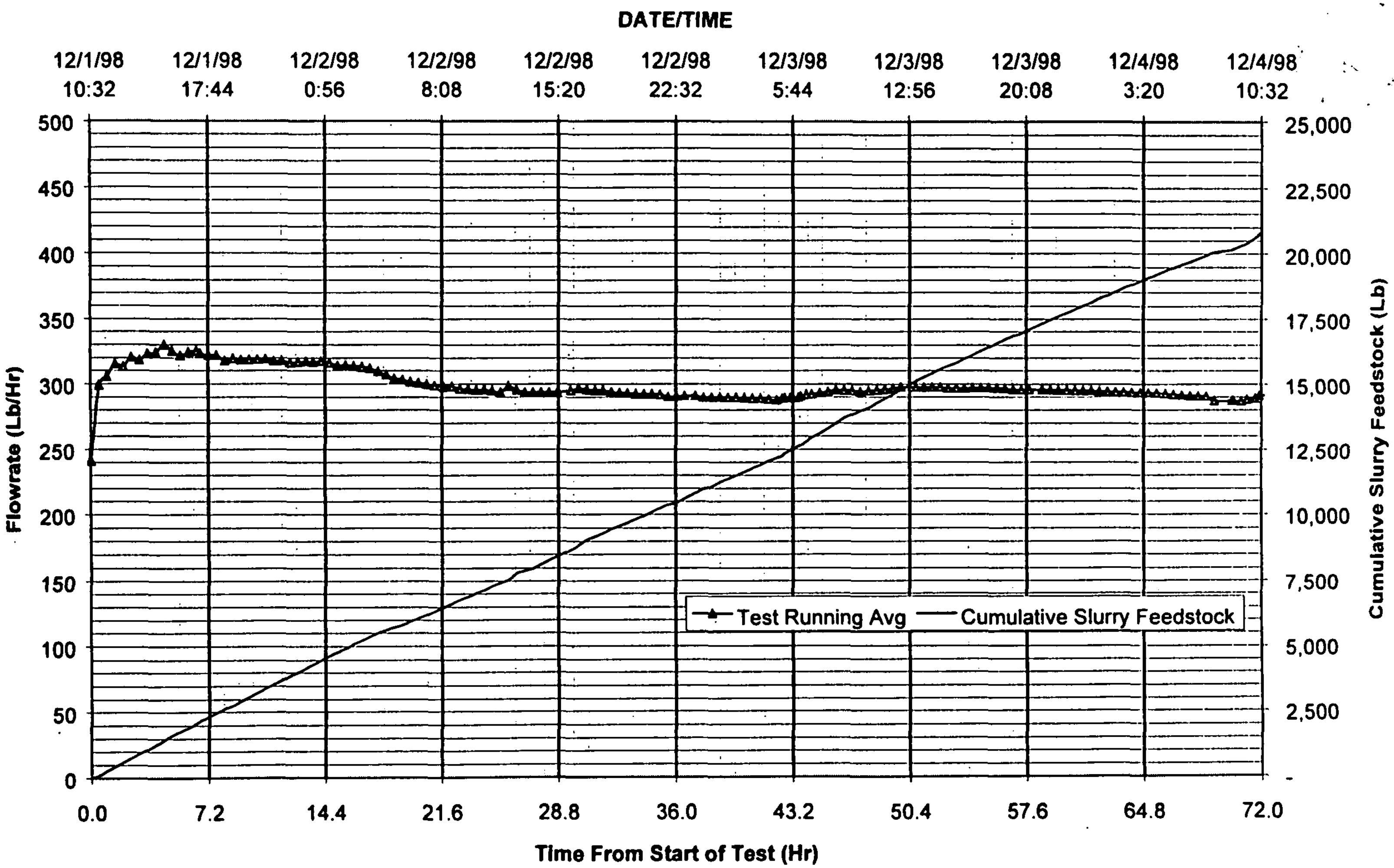

Figure 7-2. Average and Cumulative DSF Feedrate Versus Time Over Proof of Principle Test

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The CMS™ was at steady state operating temperature, nominally 1,288°C (2,350°F), on the morning of December 1. Samples of the DSF for population 1 were taken from the recirculation line of the DSF feed tank before initiation of DSF flow to the CMS™. Sample containers were labeled and stored by Horizon in accordance with the sampling and chain of custody procedures. The specific gravity of a DSF sample was measured by Vortec personnel for use in calculating the DSF flow rate to the CMS™. The sampling and specific gravity measurement procedures were repeated for each population approximately 1 hour prior to the start of the population throughout the test. At FDF's request, a DS slurry sample was also taken from the recirculation line of the 2,000 gallon DS slurry storage tank prior to starting the test.

The speed of the DSF feed pump was set to achieve a DSF flowrate to the CMS™ of approximately 126 kg/hr (278 lb/hr). DSF feed to the CMS™ was then initiated at 10:32 a.m. The drop in level of DSF in the feed tank was measured at 30 minute intervals throughout the population period and the DSF flowrate calculated. This procedure was followed for each of the subsequent population periods. The speed of the DSF feed pump was changed as necessary during the test to maintain the design DSF throughput.

At 12:30 p.m., December 1, glass began coming out of the tap hole in the bottom of the separator/reservoir. The viscosity of the glass appeared to be satisfactory for continued operation at the design temperature. Patty samples of the glass were taken at one hour intervals and a frit sample was taken four hours after glass flow was observed discharging from the tap hole. Vortec personnel continued to take patty samples at one hour intervals throughout the test and one glass frit sample during each population approximately four hours after the beginning of the population. The samples were packaged and preserved in accordance with the sample chain of custody procedures.

Particulates in the flue gas from the CMS™ downstream of the evaporative cooler were taken by CSC during each population. At the same time, flue gas samples were taken for analysis of SO_2 concentration. The duration of each sampling period was approximately one hour, beginning about four hours after the start of the population period. Particulate samples were turned over to Horizon for packaging and preservation in accordance with the sample chain of custody procedures. CSC maintained custody of the flue gas sample and performed the analysis for SO_2 concentration.

During the 4th population period, on December 2, approximately 27 hours after the start of the test, a fuse in the DSF feed pump dc motor speed controller failed, interrupting power to the pump. A replacement fuse was installed, and the total interruption in DSF feed to the CMS™ was limited to seven minutes. During this time, the natural gas and air flow rates to the CMS™ were adjusted in response to changes in system temperature. This can be observed in the plot of temperature and natural gas flow rate versus time in Figure 7-3. At approximately 13:38 (27.15 hrs after the start of the test) the temperature started to increase as a result of termination of DSF feed to the CMS™. The operator decreased natural gas input to the system to decrease the temperature to the design level. This was accomplished in less than five minutes. At approximately 13:49, the system temperature began to decrease in response to reintroduction of DSF feed into the CMS™. The operator responded with an increase in natural gas flow to recover temperature and followed with adjustments to the natural gas input to stabilize the temperature within the design operating range. From the time the DSF feed was restarted until the system was re-stabilized was about 20 minutes.

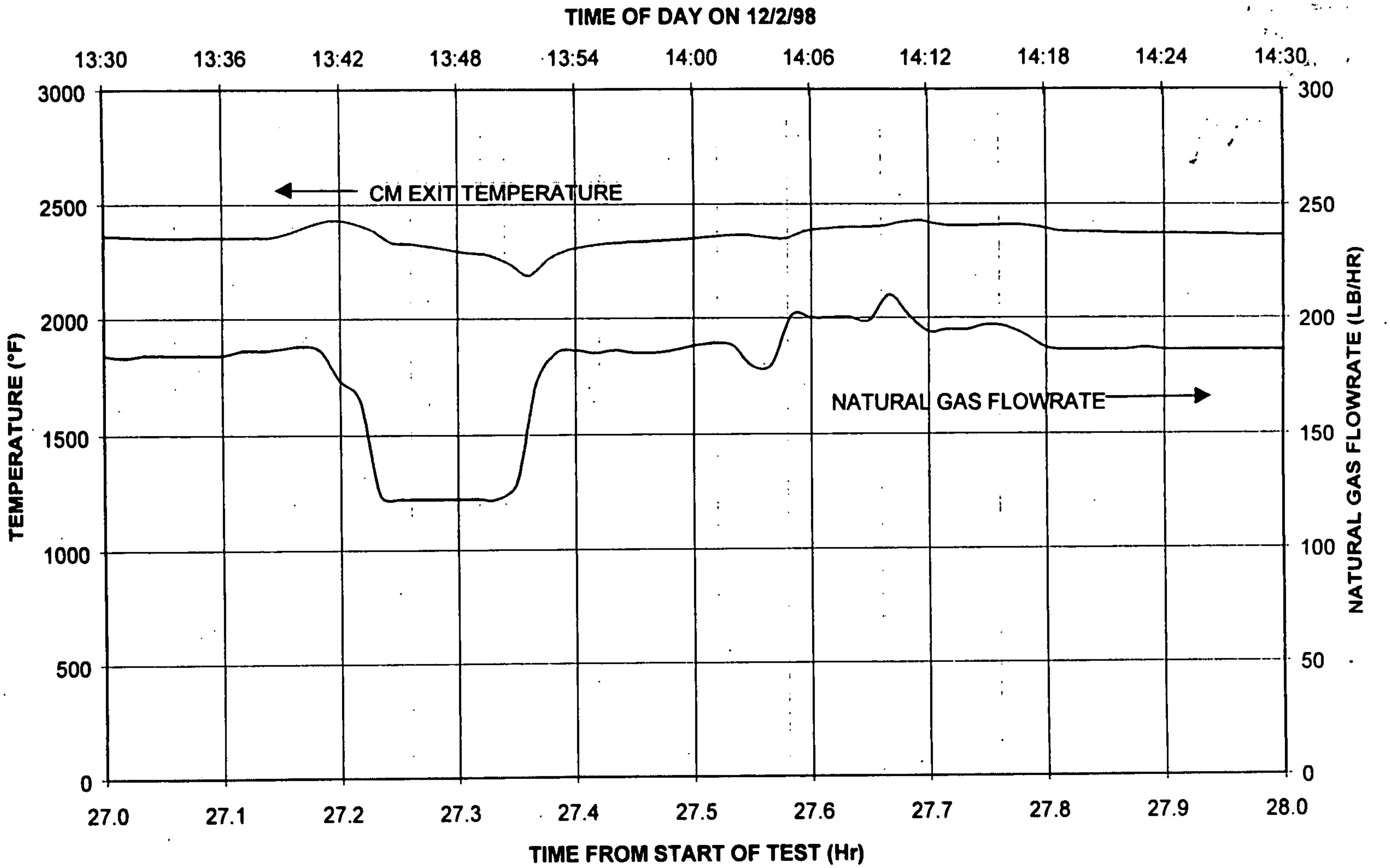

Figure 7-3. Natural Gas and Melter Gas Temperature During 4th Population from 27 Hrs to 28 Hrs After Test Start

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Also during the 4th population period, approximately 29.3 hours after the start of the test, the system operator in the control room noticed a rise in CRV reactor gas temperature of about 50°F over a short period of time (about 2 minutes) to a temperature of about 2,400°F. A plot of reactor temperature, melter temperature, and natural gas flowrate versus time for this period is shown in Figure 7-4. Since the design operating temperature range was established as 2,300°F to 2,400°F, the operator notified the test engineer of the increase. The test engineer became concerned that the DSF feed line to the CMS™ may be starting to plug. Therefore, water was introduced into the line to dilute the DSF and clear any blockage [a service water connection was installed in the line prior to the test so that flush water could be introduced in case plugging occurred]. During the time that water was added, the natural gas flow to the system was increased to offset the added thermal energy required to vaporize the water and maintain the system temperature in the design range. After five minutes, the water addition was terminated and DSF flow appeared to be normal. The thermal input to the system was then adjusted to restore the system to normal operating temperature. No interruption of feed to the CMS™ occurred during this period.

During the 8th population period on December 3 (about 52 hours after the start of the test), a decision was made by Vortec to remove the slurry injector from the CMS™, replace it with a spare one, and inspect the original injector for wear. At the end of hot checkout tests of a similar injector conducted a month earlier, there were signs of wear at the injector nozzle. The materials of construction of the injector for the 72-hour Proof of Principle Test were selected considering the duration of the test and cost, and were not optimized for long term commercial operation. Inspection of the injector was originally scheduled to occur during the 2nd population period; however, since there were no apparent problems, Vortec decided to postpone the inspection until later in the test. This activity entailed terminating DSF feed to the CMS™; flushing the DSF feed line and injector with water; increasing the system induced draft (ID) fan speed to its maximum and reducing the air from the forced draft (FD)fan to the CMS™ until a negative pressure was achieved in the CRV reactor; removal of the injector from the CRV reactor lid; installation of a replacement injector into the CRV reactor lid; and restoring normal operating conditions. The total duration of the activity from termination to restart of DSF feed to the CMS™ was three minutes.

Inspection of the original injector revealed that there was some wear around the nozzle. It was also observed that the nozzle in the injector was apparently assembled prior to the test such that the gap for slurry flow was much larger than intended for optimum atomization. However, any adverse impact on the performance of the CMS™ during the time that the injector was installed was not apparent. After inspection of the original injector, the test engineer observed, through a site port installed in the lid of the reactor, the slurry entering the CRV reactor and noted that atomization did appear to be somewhat better with the newly installed injector. However, there did not appear to be any effect on the measured system parameters. This may have been because the system was being operated at a throughput considerably below the maximum capability of the system to minimize the cost of feedstock materials.

After DS slurry and glass additives for the 10th population were transferred to the DSF feed tank on December 4, the inside of the 2,000 gallon DS slurry storage tank was cleaned out with water. This water was contained within the storage tank and then transferred to the DSF feed tank and added to the population 10 DSF.

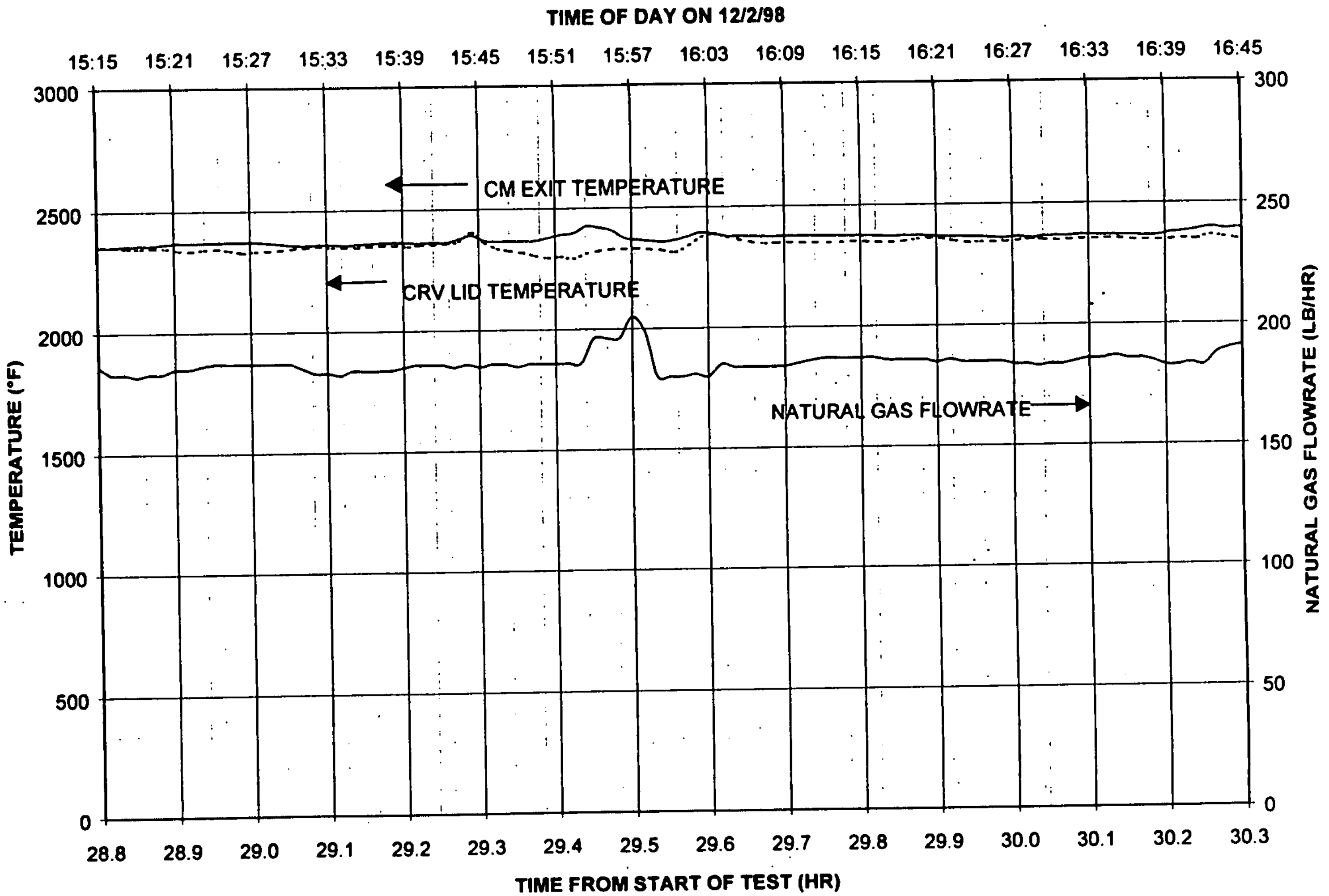

Figure 7-4. Natural Gas and Gas Temperatures During 4th Population from 28 Hrs to 30 Hrs After Test Start

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After all the 9th population DSF was fed to the CMS™, the feed valve from the 9th population DSF tank was closed and the valve from the 10th population tank simultaneously opened. However, DSF did not immediately start to flow from the 10th population tank due to a blockage in the quick disconnect hose from the tank to the pump. Vortec personnel at the tank location quickly disconnected the hose, cleared the blockage, reconnected the hose, and restored flow to the pump. The total interruption of DSF feed to the CMS™ during this time did not exceed three minutes.

After about two hours into the 10th population period (about 68 hours into the test), the hose from the DSF feed tank to the pump again plugged. This was evident by a change in the sound of the pump as noticed by personnel at the feed station. The hose was again disconnected, the blockage cleared, and the DSF feed returned to normal. The duration of DSF feed interruption during this period was about five minutes.

Near the end of the 10th population period, the other DSF feed tank was washed out with water. The water was then transferred into the DSF feed tank with the population 10 DSF and also processed through the CMS™.

During the 10th population period, it was apparent that if the DSF feed rate was maintained constant, the length of time it would take to feed the remaining DSF with the added cleaning water would result in the test being several hours longer than the intended 72 hours. Therefore, the DSF feed rate to the CMS™ was increased from approximately 113 kg/hr (250 lb/hr) to 235 kg/hr (518 lb/hr) for the last 1.5 hours of the test. All of the DSF for the 10th population was processed through the CMS™ at 11:04a.m. on December 4, 1998, for a total Proof of Principle Test duration of about 72.5 hours.

The CMS™ demonstrated its stable operation capability throughout the test. Typically the operating temperature was maintained within 50°F of the design temperature (refer to Figure 7-1). At times when the flow rate of DSF to the CMS™ was adjusted or when DSF feed interruptions occurred resulting in changes in operating temperature, the system responded rapidly to operator input and quickly (typically within 10 to 20 minutes) restored to normal operating temperature. As a result, no excursions above safe operating temperatures, defined as temperatures above which damage to refractory or other components would occur, were encountered. Additionally, the temperature was maintained above a level that would adversely affect glass flow or glass characteristics.

7.4 TEST DATA ANALYSIS

7.4.1 Heat and Mass Balance Data

DSF, glass, and flue gas particulate samples from Populations 2, 5, and 9 were analyzed for chemical composition. Heat and mass balances were performed using the analytical data in conjunction with measured and calculated stream flow rates. Results of the chemical composition analyses and constituent mass balance calculations are presented in Table 7-4. Process flow diagrams with heat and mass balance data are presented in Figures 7-5 through 7-7.

Table 7-4. 72-Hour Proof of Principle Test Mass Balance Data

Constituent	DSF (Lbs/Hr) Pop #2	Pop #5	Pop #9	Average	Partioning to Flue Gas (Lbs/Hr) Pop #2	Pop #5	Pop #9	Average
Fluxes - Alkali	13.24	10.34	10.66	11.41	0.64	0.65	0.89	0.73
Fluxes - Alkaline	10.65	7.49	12.86	10.34	0.65	0.56	0.73	0.65
Glassformers								
Al2O3	3.73	2.59	3.70	3.34	0.15	0.10	0.14	0.13
Al2O3 (from refractory erosion)								
SiO2	51.73	52.64	35.32	46.56	1.24	1.06	1.44	1.25
Special Interest								
PbO	9.48	7.95	10.73	9.39	3.57	4.68	5.44	4.56
SO3 - Sulfate Solid	4.20	2.93	4.19	3.77	1.39	1.72	1.96	1.69
P2O5 - Phosphate	1.85	1.45	1.29	1.53	-	-	-	-
Other	19.06	15.85	21.56	18.83	0.16	0.12	0.19	0.16
Total Solids	113.95	101.23	100.33	105.17	7.80	8.90	10.80	9.17
H2O (Liquid)	194.02	172.36	170.83	179.07				-
SO3 (gas)					1.88	0.75	0.50	1.04
Others (CO2, NOx, etc.) (gas)					16.43	13.93	18.68	16.35
H2O (gas)					194.02	172.36	170.83	179.07
Total Non-solids	194.02	172.36	170.83	179.07	212.34	187.04	190.01	196.46
Total All	307.98	273.58	271.15	284.24	220.14	195.94	200.81	205.63

Constituent	Glass, Calculated (Lbs/Hr) Pop #2	Pop #5	Pop #9	Average	Glass, Calculated (%) Pop #2	Pop #5	Pop #9	Average	Glass, As Analyzed (%) Pop #2	Pop #5	Pop #9	Average
Fluxes - Alkali	12.60	9.68	9.77	10.69	13.71%	11.85%	12.88%	12.81%	9.89%	10.99%	13.43%	11.44%
Fluxes - Alkaline	10.00	6.93	12.13	9.69	10.88%	8.48%	15.99%	11.78%	13.38%	13.37%	16.17%	14.31%
Glassformers												
Al2O3	3.58	2.49	3.56	3.21	3.89%	3.04%	4.70%	3.88%	8.35%	8.00%	11.98%	9.44%
Al2O3 (from refractory erosion)	4.10	4.05	5.53	4.56	4.46%	4.96%	7.28%	5.57%		Included in Al2O3 above		
SiO2	50.49	51.58	33.88	45.32	54.92%	63.14%	44.65%	54.24%	56.91%	57.44%	47.68%	54.01%
Special Interest												
PbO	5.91	3.26	5.29	4.82	6.43%	4.00%	6.98%	5.80%	5.91%	5.17%	5.29%	5.46%
SO3 - Sulfate Solid	0.94	0.45	1.73	1.04	1.02%	0.55%	2.28%	1.28%	0.40%	0.25%	0.17%	0.27%
P2O5 - Phosphate	1.85	1.45	1.29	1.53	2.01%	1.77%	1.71%	1.83%	1.23%	1.25%	1.54%	1.34%
Other	2.47	1.80	2.68	2.32	2.69%	2.20%	3.54%	2.81%	3.93%	3.53%	3.74%	3.73%
Total Solids	91.94	81.69	75.67	83.17	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Input Streams (Lbs/Hr)

Constituent	Pop #2	Pop #5	Pop #9	Average
DS Dry Basis	83.15	73.87	73.21	76.74
Additives	30.80	27.36	27.12	28.42
Water	194.02	172.36	170.83	179.07
Total DSF	307.98	273.58	271.15	284.24

Output Streams (Lbs/Hr)

Constituent	Pop #2	Pop #5	Pop #9	Average
Glass	91.94	81.69	75.87	83.17
Particulate Carryover	7.80	8.90	10.80	9.17
Off-Gas	212.34	187.04	190.01	196.46
Refractory	(4.10)	(4.05)	(5.53)	(4.56)
Total	307.98	273.58	271.15	284.24

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FDF 72 HOUR TEST POPULATION #2 12/1/98

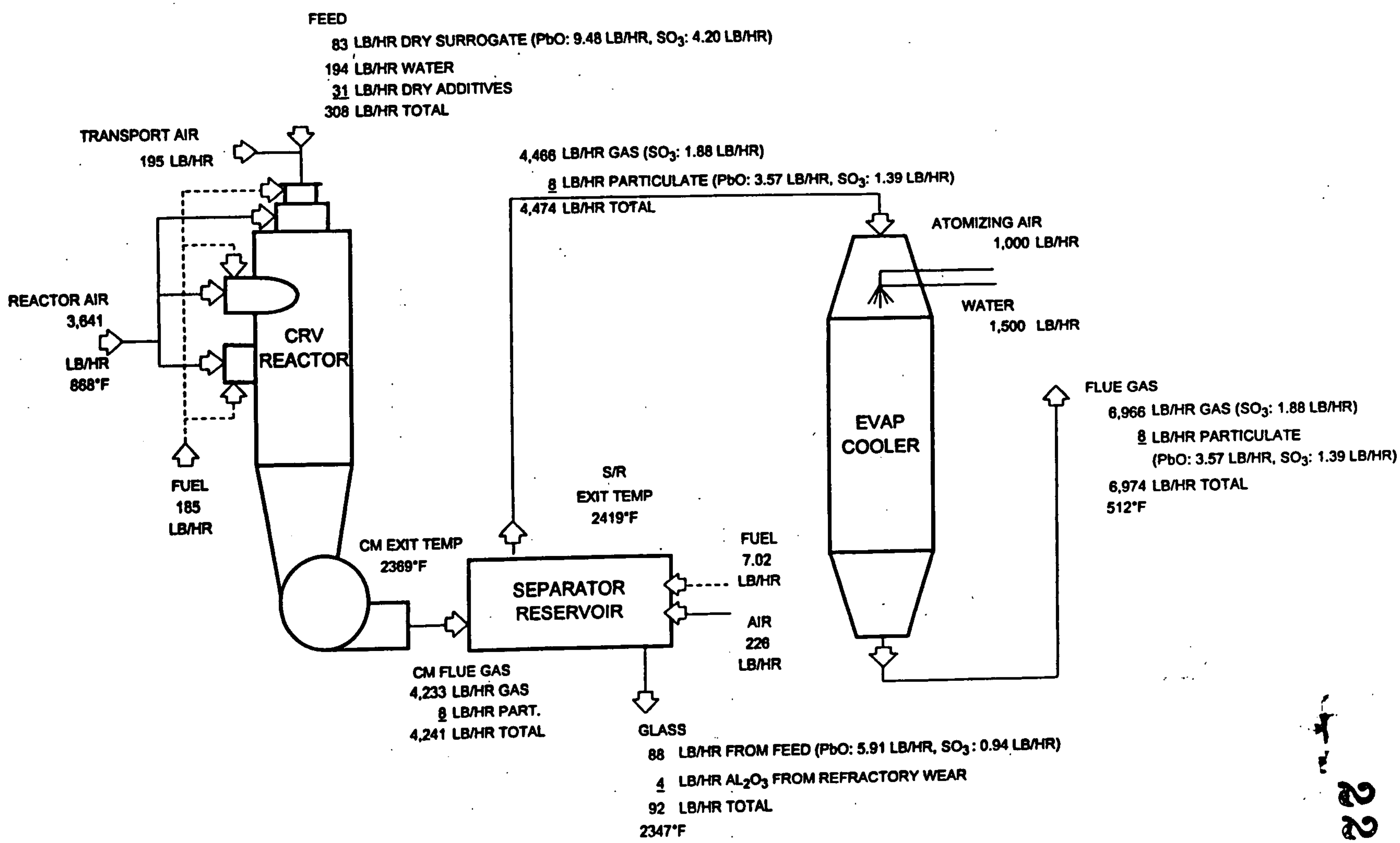

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Figure 7-5. Proof of Principle Test Process Flow Data for Population #2

DLQ 6/1/99

FDF 72 HOUR TEST POPULATION #5 12/2/98

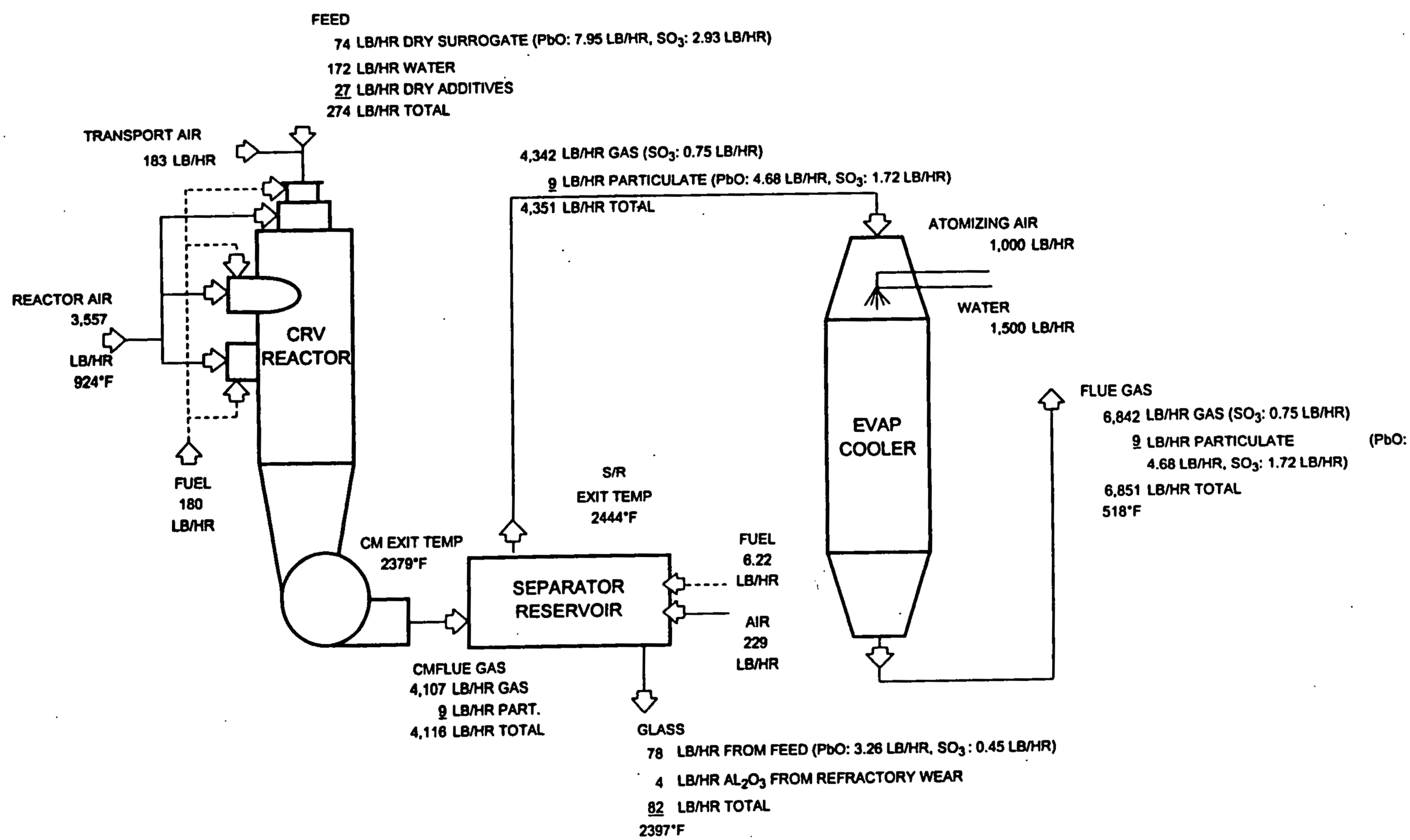

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Figure 7-6. Proof of Principle Test Process Flow Data for Population #5

DXG 6/1/99

FDF 72 HOUR TEST POPULATION #9 12/4/98

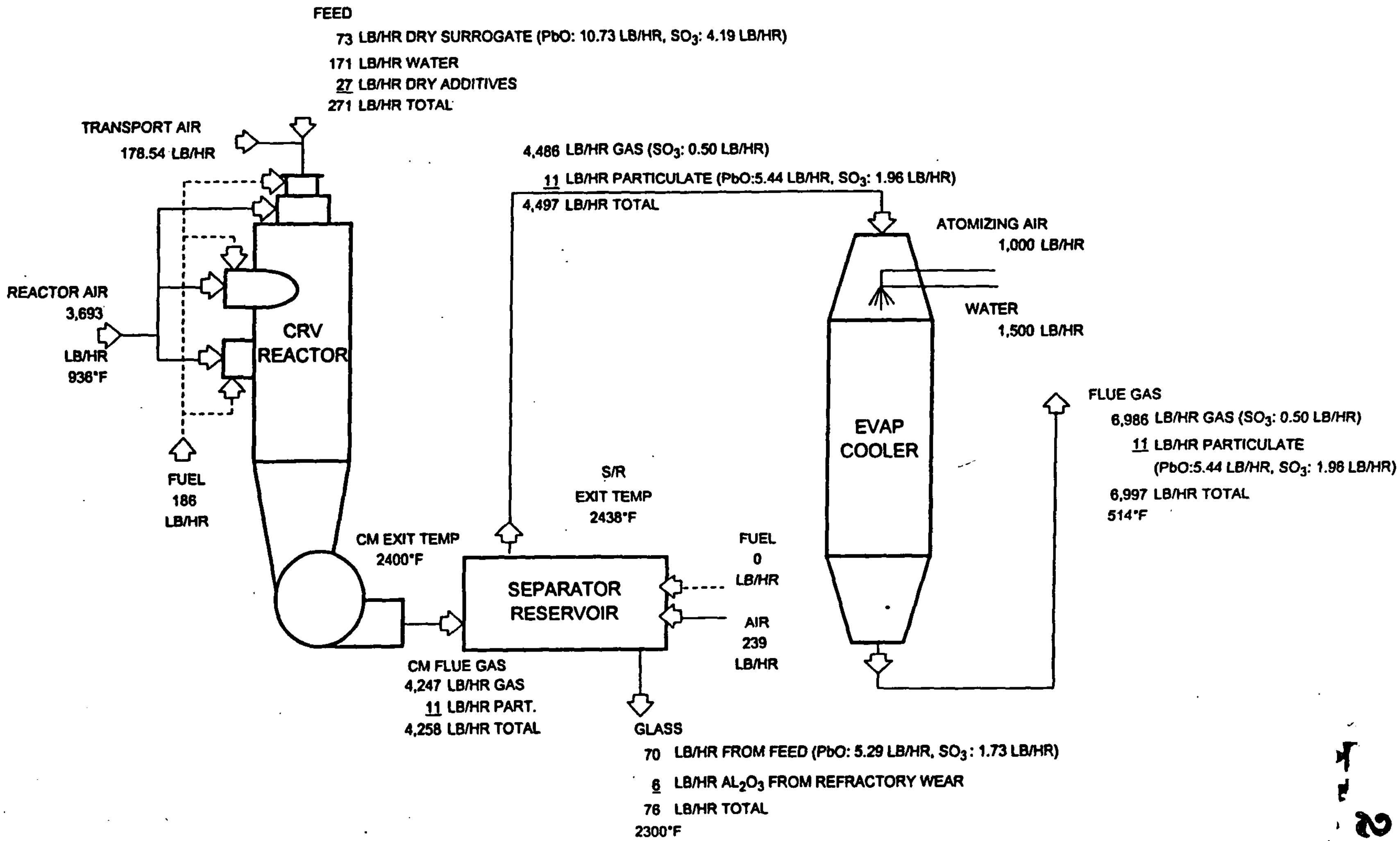

Figure 7-7. Proof of Principle Test Process Flow Data for Population #9

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The mass flow rates for the constituents in the DSF and flue gas were calculated based on the concentrations determined by the chemical composition analyses and the average flow rates measured during the approximate 1 hour periods in which flue gas sampling occurred. The particulate in the flue gas was found to be about 6.8% of the solids in the DSF for Population 2, 8.8% for Population 5, and 10.8% for Population 9.

The mass flow rates for constituents in the glass were calculated based on the differences between those in the DSF and those in the flue gas. The concentrations of the constituents in the glass were then calculated based on the calculated flow rates, and are compared with the concentrations from the CELS chemical composition analyses in the tables. The data demonstrate that from 41% to 62% of the lead in the DS slurry was retained in the glass.

The Al_2O_3 concentration in the glass as analyzed by CELS was significantly higher than that calculated by the difference in Al_2O_3 entering the process in the DSF and that leaving the process in the flue gas particulate. This could be the result of erosion of the Alumina-Zirconia-Silica (AZS) refractory in the pilot-scale CMS™. This type of refractory is used in the pilot-scale test system, which undergoes frequent rapid start-up and shutdown, because of its thermal shock resistance, and may not be the optimal refractory for a commercial system processing Silo 1 and 2 residue.

Process flow diagrams showing total input and output flow data and temperature conditions are presented in Figures 7-5 through 7-7 for Populations 2, 5, and 9. Again, these data are based on average conditions for the period of time (about one hour) during which flue gas sampling and analysis was performed. The ratio of the quantity of dry surrogate fed to the process to the combined quantity of glass and particulates from the system ranged from 0.85 to 0.90 for Populations 2, 5, and 9.

7.4.2 Continuous Flue Gas Composition Data

A Vortec managed flue gas instrumentation system provided for on-line continuous measurement of CO, O_2, SO_2, and NO_x concentrations in the flue gas downstream of the separator/reservoir (before the evaporative cooler). These data are presented in Figure 7-8 for the 72-hour test period. The NO_x and CO concentrations in the flue gas were typically about 100 ppm by volume of dry gas. Normally, a system using reaction air preheat temperatures on the order of 1,000°F would have very high concentrations of NO_x (>1000 ppm). However, the rapid quenching of the gas in the Vortec CMS™ by the feedstock injected directly into the reaction zone limits the time that the gas is at high NO_x forming temperatures. The SO_2 in the flue gas was typically in the range from 200 to 250 ppm by volume of dry gas, while the O_2 concentration was nominally 6% by volume. At about 1:00 p.m. on December 3, the O_2 analyzer temperature control unit began to malfunction. The analyzer was turned off, and a field technician (outside contractor) was called in to evaluate the problem and make necessary repairs. The technician completed repairs at about 9:00 p.m. on December 3, and the analyzer was brought back online.

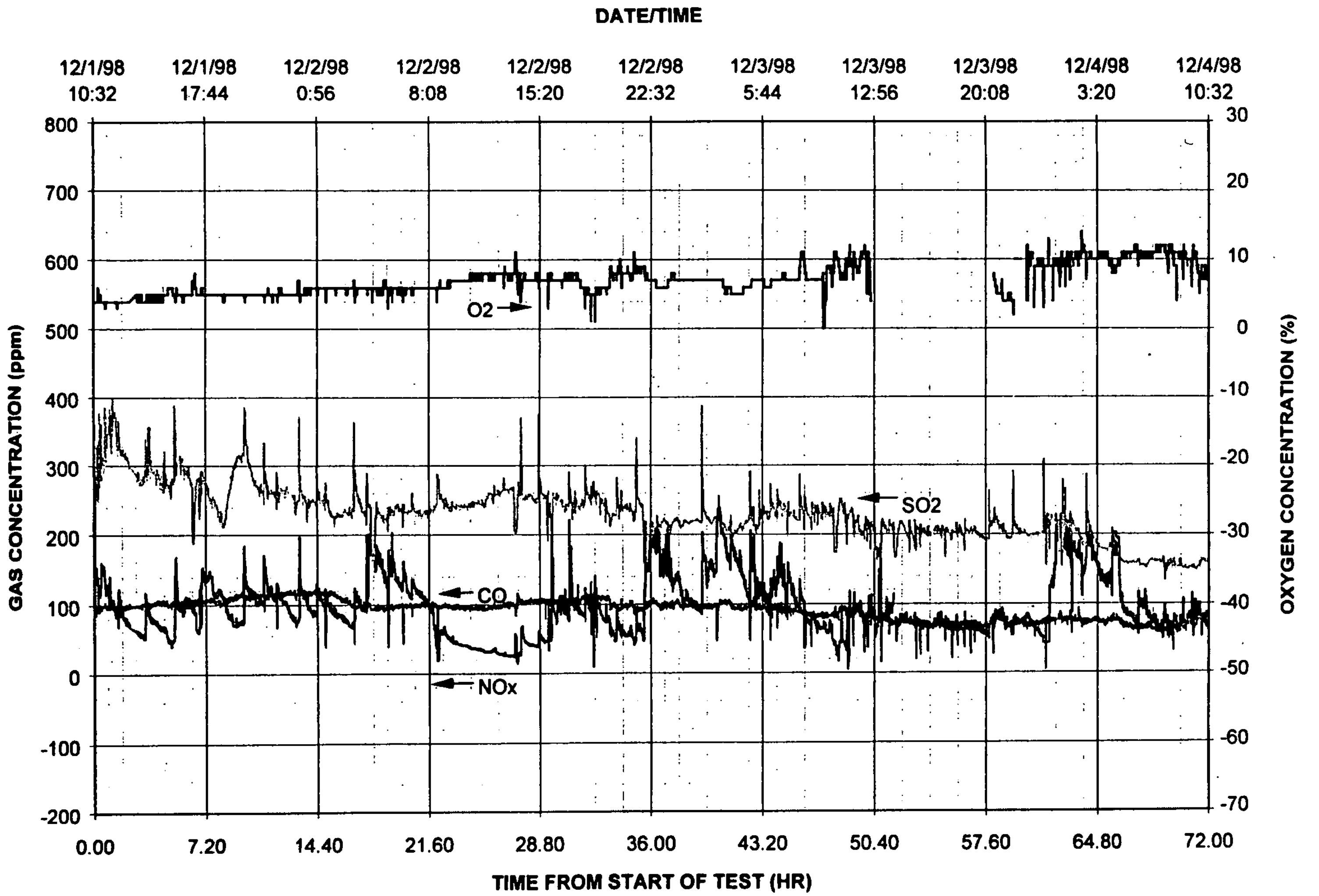

Figure 7-8. Proof of Principle Test Flue Gas O_2, CO_2, SO_2, and NO_x Data

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7.4.3 Glass Leaching Analysis

Glass samples from Populations 2, 5, and 9 were subjected to the TCLP to determine the leachability of RCRA metals from the glass. The concentrations of metals in the leachate from the TCLP for each of the are presented in Table 7-5 along with the RCRA limits in 40 CFR Part 261.24. All concentrations were less than one-half the RCRA limit for toxicity, the criteria for success established by FDF.

The concentration of lead in the leachate, of particular interest to FDF, ranged from 0.42 to 0.93 mg/l, less than one-fifth the RCRA limit. It is anticipated that the higher concentration of Pb in the leachate from the Population 9 sample relative to that from the Population 2 and 5 samples is because of the difference in glass composition. The Pb leachate concentration is a function of the amount of PbO in the glass and the glass composition. The glass composition controls the glass structure, which determines how tightly the Pb ions are bound to the glass. The Pb concentration for the Population 9 glass is similar to that for Populations 2 and 5; however, the SiO_2 concentration is lower in the Population 9 glass and the alkali and alkaline earth metal oxide fluxes are higher. According to a structure model used to relate the glass compositions to the glass durability, the higher SiO_2 concentration and lower alkali and alkaline earth metal oxide fluxes should result in an increase in the Pb leachate level, as observed. A more detailed discussion of the model and results are presented in Section 7.3 of the Silo 1 and 2 Proof of Principle Final Report.

Table 7-5. Proof of Principle Test Glass TCLP Results

	Concentration in Leachate, mg/l			
Metal	**Population 2**	**Population 5**	**Population 9**	**40 CFR 261.24**
Arsenic	<0.087	<0.087	<0.087	5.0
Barium	0.22	0.29	0.89	100.0
Cadmium	<0.024	<0.024	<0.024	1.0
Chromium	<0.055	<0.054	<0.054	5.0
Lead	0.46	0.42	0.93	5.0
Mercury	<0.00075	<0.00075	<0.00075	0.2
Selenium	<0.20	<0.20	<0.20	1.0
Silver	<0.023	<0.022	<0.022	5.0
Antimony	<0.10	<0.10	<0.10	NA
Beryllium	-	-	-	NA
Nickel	<0.026	<0.027	<0.053	NA
Thallium	-	-	-	NA
Vanadium	-	-	-	NA
Zinc	<0.023	<0.023	<0.023	NA

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8.0 SUMMARY AND CONCLUSIONS

Vortec Corporation successfully demonstrated the suitability of its CMS™ technology for the treatment of silo residue at Fernald via a 72-hour Proof of Principle test conducted in Vortec's pilot-scale CMS™ facility. Approximately 8,376 kg (18,469 lb) of DS slurry, containing 30% solids, was prepared and processed, exceeding FDF's throughput criteria of 2,600 kg/day. Approximately 9,570 kg (21,104 lb) of DSF (DS slurry and additives), including the additional cleanup water added to the last population, was processed over the duration of the test, resulting in an average DSF processing rate of about 3,167 kg/day (6,984 lb/day). A DSF throughput of 235 kg/hr (518 lb/hr), equivalent to a daily processing rate of 5,640 kg, was achieved for the last 1.5 hours of the test. The demonstrated availability of the CMS™ process over the 72-hour test was 99.59% compared to FDF's minimum criteria of about 95%.

Approximately 2,676 kg (5,900 lb) of glass was produced during the test. Forty to sixty percent of the lead introduced into the system partitioned to the glass; the remainder partitioned to the flue gas. Samples of the glass were subjected to the U. S. EPA's TCLP. TCLP results demonstrated metals concentrations in the leachate less than one-fifth of the limits established by RCRA for toxicity in 40 CFR Part 261.24. The concentration of lead in the leachate, of particular interest to FDF, ranged from 0.42 mg/l to 0.93 mg/l, satisfying the FDF established criteria of less than 2.5 mg/l.

No problems were encountered with the CMS™ process during the test. Other than a scheduled changeout and inspection of the slurry injector in the system, resulting in a DSF feed interruption of only 3 minutes, all interruptions were a result of slurry handling difficulties prior to introduction of the slurry into the CMS™ process. The operating temperature was generally maintained within ±50°F of set point, more than sufficient for system operability and glass quality control. A tighter tolerance, on the order of ±25°F, can probably be maintained in a commercial system with automated temperature control; that is, with the natural gas and reaction air input to the system computer controlled to maintain an operating temperature set point. Overall, the results of the 72-hour Proof of Principle test were similar to Vortec's expectations.

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SILO 1 AND SILO 2 PROOF OF PRINCIPLE PROJECT

APPENDICES C and D

Contract No. FDF 98WO002241
Report No. BFA-4200-809-002
Fernald Submittal No. 40720-2241-C5-004

SUBMITTED TO:
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SILO 1 AND SILO 2 PROOF OF PRINCIPLE PROJECT

APPENDIX C

Foster Wheeler Proof of Principle Conceptual Design

Contract No. FDF 98WO002241
Report No. BFA-4200-809-002
Fernald Submittal No. 40720-2241-C5-004

SUBMITTED TO:
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FOSTER WHEELER

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Purchase No. 42009

Silos 1&2 Proof-of-Principle Testing

Remediation of Silos 1&2 Residues Using Vortec Cyclone Melting System (CMS™)

Draft
Title I Design

TO

Vortec Corporation
3770 Ridge Pike
Collegeville, Pennsylvania

December 24, 1998

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EXECUTIVE SUMMARY

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS™)

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

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FOSTER WHEELER ENVIRONMENTAL CORPORATION

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FDF Vortec Commercial Scale CMS™

EXECUTIVE SUMMARY
for the
Remediation of Silo 1 & 2 Residues
Using the Vortec Cyclone Melting System

This Proof of Principle conceptual design, for the Silos 1 & 2 Proof of Principle Testing for the remediation of Silos 1 and 2 residues using the Vortec Cyclone Melting System™ (CMS™) presents the preliminary design documents and drawings for the full-scale facility. These documents include the Design Requirements Document, Process Description, Equipment List, Instrument List, Environmental Review, Regulatory Review, Safety Review, Design Drawings, and Construction Cost Estimate.
The design for the full-scale system ensures the capability to process approximately 6,780 m^3 of waste (combined uranium ore residue and Bento Grout™) originating from the Silos 1 & 2, and to be stored in the Transfer Tank Area (TTA), in 36 months, while complying with the regulatory, environmental, and safety requirements. The operating schedule will be 24 hours/day, 7 days/week, and with a 70% operational availability. The system has been designed, requiring only minor modifications, to accommodate a maximum through-put rate enabling the processing of the silo material in only 18 months; or one-half the required treatment schedule of 36 months.

The system provides a robust capacity to treat the feed material and is designed to provide operational reliability, system redundancy, and minimize system maintenance requirements. Well demonstrated, proven equipment is selected in the design. Dual feed dewatering and drying trains are utilized in feed preparation equipment, and redundant pumps are utilized in the Air Pollution Control (APC) equipment to improve maintenance capabilities, operational flexibility, and provide greater operational reliability. The plant design minimizes the potential for slurry piping pluggages and accommodates cleanout of plugged pipes. Also, the feed preparation operation is largely decoupled from the Vortec CMS™ operation, allowing for the storage of up to 7 days of prepared feed for CMS™ operations.

The Design Requirements Document includes the design parameters as well as the applicable codes and standards that were taken into account during the conceptual design. This includes information on the process, critical data used in the design and selection of mechanical equipment, structural items, civil items, electrical equipment and instrumentation. Also included is a narrative on the process control philosophy.

The Process Description provides a written description of how the tank waste derived from Silos 1 and 2 will be processed by the full-scale facility. This process description is presented by subsystem, which includes the Feed Preparation System, Vortec Vitrification Cyclone Melting System™ (CMS™), Vitrified Product Handling System, Air Pollution Control System, Wastewater Treatment System, Central Control System, and Utility System. Each subsystem is described and broken into components as the material is traced through the treatment process.

The Equipment List provides a tabulation and description of the principal equipment to be utilized, cross referenced to the design drawings. The Instrument List provides a tabulation and description of all the instrumentation to be utilized cross referenced to the design drawings. Additionally, the Instrument List provides a suggested vendor to be utilized, the instrument function, and signal type.

The Environmental Review provides a listing of the key state and federal regulations and Applicable or Relevant and Appropriate Requirements (ARARs) that are incorporated into the design or would be required to be incorporated into the construction and operation of the facility concerning air and water discharges. Additionally, the methodologies for compliance are discussed for each facility subsystem.

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The Regulatory Review includes the key state and federal regulations and ARARs which are deemed necessary to ensure the protection of human health and the environment. Additionally, the permits for construction and operation are discussed.

The Safety Review is segregated into the two separate phases of work, construction and operation. These two phases are further segregated into the various specific tasks to be performed within each phase and each task examined for health and safety concerns to be addressed during the project design, construction, and *implementation.*

The following fourteen Design Drawings are included in the conceptual design:

- Site Plan–provides a layout of the newly constructed remediation facility on the site, along with some of the civil site features.
- General Arrangement Plans, Floors 1 through 6–provides layouts of all equipment required to support the process, by floor. These layouts identify the segregation of work areas, take into account accessibility of equipment, and provide for a planned location of items which will allow the necessary space for access and routine maintenance.
- General Arrangement Sections, 2 sheets–provides four sections of the general arrangement drawings and depicts the equipment configuration in relationship to each other.
- Electrical One Line Diagram–delineates the power requirements for the project based on the loads for the mechanical process equipment and all other necessary power requirements, such as lighting and control power as well as identifying the individual circuits for each piece of process equipment.
- Process and Instrumentation Diagram–includes a diagrammatic depiction of the various systems required to support the process, including the instrumentation and control equipment and their relationships to each other.
- Process Flow Diagram, 2 Sheets–provides the definition of the complete process flow.
- End Product Handling Schematic–provides a diagrammatic depiction of the steps taken with the storage/shipping casks and packaging of the resultant glass product.

The Construction Cost Estimate provides a base preliminary cost estimate for construction of the full-scale remediation facility based on the conceptual design utilizing all newly purchased equipment; and two option cost estimates. The first option prices the construction of the facility using used equipment for some components of the system, (e.g. the drier screws). The second option provides a cost estimate that includes doubling the capacity of the Air Pollution Control (APC) System.

A discussion of the analysis of radon removal efficiency and associated air flows is included as Appendix A. This discussion concludes that there is sufficient flexibility and conservatism in the planned Radon Control System (RCS) associated with the Accelerated Waste Retrieval (AWR) project to accommodate additional flow, and that using that flexibility is less costly than providing for additional radon treatment. Appendix B provides the data sheets for the major pieces of equipment.

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DESIGN REQUIREMENTS DOCUMENT

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS™)

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

FOSTER WHEELER ENVIRONMENTAL CORPORATION

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FDF Vortec Commercial Scale CMS™

DESIGN REQUIREMENTS DOCUMENT
for the
Remediation of Silo 1 & 2 Residues
Using the Vortec Cyclone Melting System

1.0 INTRODUCTION

This Design Requirements Document (DRD) specifies the performance expectation of the full-scale facility to process residue at the U.S. Department of Energy's (DOE) Fernald Ohio site from Silos 1 and 2 in approximately 36 months of operation. The purpose of the design data provided in this DRD is to support the preliminary Fluor Daniel Fernald (FDF) design basis of a full-scale remediation facility. The permitting requirements, DOE orders, and codes that will apply to operating the facility are described separately in the review of regulatory permitting requirements, Health and Safety requirements (H&S), DOE orders, and codes.

Detailed design data will be prepared in the next project phase to detail the minimum requirements for the contractor in the areas of project management, design, and documentation. Due to the radiological issues and DOE concerns, this project shall require readiness activities in accordance with DOE order 425.1 (Part 7-Section 5.0). Comprehensive documentation, evaluation, planning and training shall be required to comply with readiness requirements for this project.

The processing facility shall be designed to process 6,780 cubic meters of combined processed uranium ore residue and Bento Grout™ from Silos 1 and 2 over a three year period. The operating schedule shall be 24 hours/day, 7 days/week, and with a 70% operational availability. The process shall be capable of treating waste containing Resource Conservation Recovery Act (RCRA) and Toxic Substances Control Act (TSCA) contaminants, and radionuclides. The Air Pollution Control (APC) system shall be capable of meeting applicable DOE Orders, EPA regulations and the State of Ohio standards for the removal of hazardous materials (best demonstrated available technologies, BDAT). The facility shall also meet DOE, Occupational Safety & Health Administration (OSHA), U.S. Environmental Protection Agency (EPA) and other federal standards and regulations for compliance in safety and industrial hygiene. The glass product from the process shall meet the Flour Daniel Fernald (FDF) treatment standard for appearance, compressive strength, standing liquid, passing toxicity characteristic leaching procedure (TCLP) at 50% of current TCLP leaching rate, and shall not be classified as a hazardous waste per 40 CFR Part 261.

The interface of the processing facility with the full-scale stabilization facility is shown in Figure 1. The design requirements for the processing facility are presented by subsystems of the processing facility.

These subsystems include the following:

- Feed Preparation System
- Vortec Vitrification Cyclone Melting System™ (CMS™)
- Vitrified Product Handling System
- Air Pollution Control System,
- Wastewater Treatment System
- Central Control System
- Utility System

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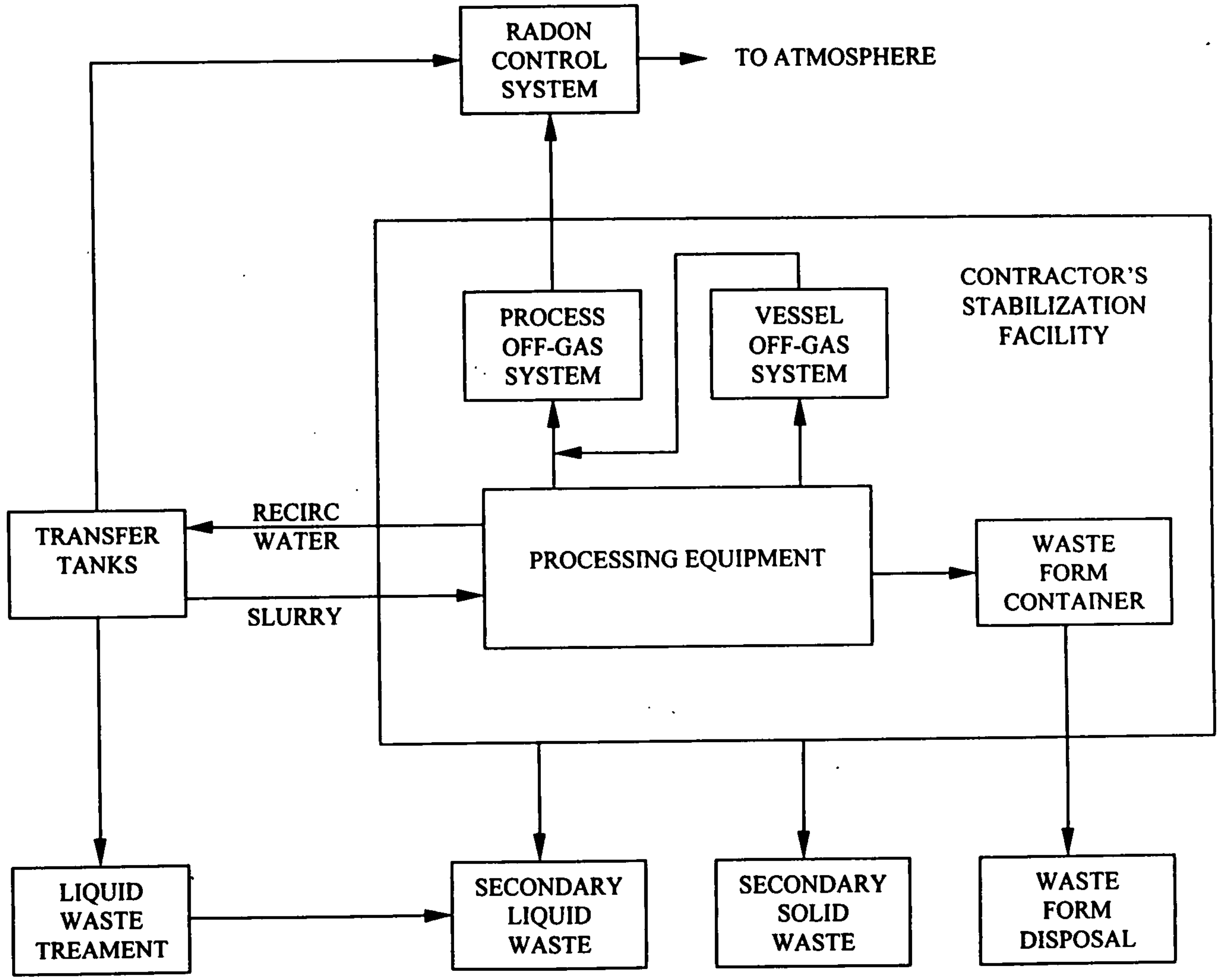

Figure 1. Full-Scale Stabilization Facility Interface Diagram

The process equipment and flow diagram for the process facility is depicted in Drawing E-4200.808.002. Equipment data sheets for each major piece of equipment are included in Addendum C. The data sheets indicate the performance requirements and material of construction selected for each component.

The system provides a robust capacity to treat the feed material and is designed to provide operational reliability, system redundancy, and minimize system maintenance requirements. Well demonstrated, proven equipment is selected in the design. Dual feed de-watering and drying trains are ultilized in feed preparation equipment, and redundant pumps are utilized in the APC equipment to improve maintenance capabilities, operational flexibility, and provide greater operational reliability. The plant design minimizes the potential for slurry piping plugging and accommodates clean out of plugged pipes. High-pressure lines sized for velocities in excess of 14 ft/sec are specified to prevent saltation. A flush water system is provided for clean-out and maintenance of all slurry lines and is further described in the utilities section. Also, the feed preparation operation is largely de-coupled from the Vortec CMS™ operation, allowing for the storage of up to 7 days of prepared feed for CMS™ operations.

The process equipment, tanks, and associated piping shall be shielded, as required, to reduce radiation exposure and vented to the radon control system (RCS), as required, to maintain radon gas control. Further discussion of the design criteria and estimated dosage rates for the major equipment are included in the system Safety Review.

2.0 FEED PREPARATION SYSTEM

The feed preparation system receives a slurry feed stream from the transfer tanks and de-waters, dries, provides storage of the dry feed, and mixes glass making additives for processing in the Vortec CMS™. Carbon steel is the material of construction for the feed preparation equipment, except for one stainless steel glass additive silo, since the pH of the slurry feed is near 8. The feed preparation equipment shall be designed to prepare a dry feed rate of 8,000 lbs/hr from the dryer, operating 4 days per week and 8 hours per day. Using this basis results in a 1,600 lbs/hr (24 hr/day, 7 days/wk) material rate which is approximately 40 percent over the CMS™ operating rate of 1,155 lbs/hr. The design requirements for each major piece of equipment in the feed preparation area are described below.

2.1 SLURRY FEED TANK

The slurry feed material (10 to 30% solids at the dry basis feed rate of 5,900 LB/hr) shall be transferred from the Tank Transfer Area (TTA) to an 8,000 gallon stirred tank sized to receive 1 hour of the 10% solids slurry stream at a flow rate of approximately 120 gpm. The tank shall be vented to the RCS to maintain the tank under slight negative pressure. Slurry feed material shall be pumped via a peristaltic pump to two centrifuges operating in parallel.

2.2 CENTRIFUGES

Two 60 gpm centrifuges, one for each dryer screw, shall be used to dewater the feed material from the slurry feed tank to about 50 wt% solids content. Each centrifuge shall be located directly above one of the dryer screws. The de-watered solid feed from each centrifuge shall discharge into one of the dryer screws. The liquid from the centrifuge (centrate) shall be pumped back to the TTA using a peristaltic pump.

2.3 DRYER SCREW SYSTEM

Two dryer screws, operated in parallel, each with four 16 foot by 24 inch diameter screws, shall dry the feed material. The dryer screws are sized to reduce the water content of a maximum of 16,000 lbs/hr solids feed material from 50 wt% to 5 wt% (8420 lb/hr dry feed). A natural gas-fired heated oil system shall provide the 9 MM Btu/hr heat duty to dry the feed material. The dryer screws shall be operated 32 hours per week, therefore based on 168 total hours per week, provides a maximum average dry feed rate of 1,600 lbs/hr dry feed.

The hot oil screws were selected for this application to minimize the air flow and dust generated from drying the feed. Treating the slurry feed directly in the CMS™ process would result in a very large APC and RCS gas loading (of approximately 4,000 acfm), resulting in approximately an 8 fold increase in the size of the RCS treatment capacity. In order to minimize the off-gas flow rate, the plant design dries the slurry feed material in the hot oil screws. Other drying equipment, e.g., hot air dryers, rotary kilns, or calciners, all would result in higher off-gas flow rates and increased dust generation and dust handling issues.

The steam evaporated from the wet feed material (approximately 16 gpm) shall be condensed in a cooled water condenser. A cooling tower shall provide the cooling water for the condenser. The condensate from the dryer feed shall be drained into the evaporative cooler make-up water tank (30,000 gallons). Any excess water shall be pumped to the scrubber system sumps for metals treatment and radon degassification, and then discharged to the AWWT system. The tank shall be vented to the RCS to maintain the tank under negative pressure.

During an emergency shutdown event, the dryer screw and heating oil will stop. The steam evaporation from the wet feed in the inlet to the dryer screw will continue for a period of time. The cooling water supply for the steam condenser shall continue by powering the cooling tower pump on the emergency power bus. If the shutdown includes the CMS™, the FD fan outlet flow bypasses the air heater and is directed into the APC system to route all vent flows into the RCS.

2.4 HAMMER MILL

A hammer mill sized for 10,000 lbs/hr feed shall reduce the dry feed material from the dryer screw to a mesh size of under 35 (~600μ). The dry material shall pass into a surge hopper for transfer into the dry feed storage silos by the dense-phase pneumatic conveyor. The mill shall be maintained under negative pressure.

2.5 PNEUMATIC CONVEYOR SYSTEM

A dense-phase pneumatic conveyor system shall be used to transfer the material from the hammer mill into the dry feed silos. The system shall include a surge hopper to receive the material from the hammer mill and lift the material approximately 80 feet up to the top of the dry feed silos. The system shall transfer material into one of the three silos approximately every 6 minutes. The material will be sampled using a pneumatic sampling device as the material is transferred. The material samples shall be analyzed to verify the glass-additive recipe required to treat the feed material. The surge hopper shall be maintained under negative pressure.

The pneumatic system provides the most reliable and maintenance-free transfer system available to elevate the dried feed material to the dry feed silos. The pneumatic system avoids the uses of very long screw, belt, or bucket elevator systems. A 200 scfm pulse of compressed air is used to transfer a batch of the feed material from the hammer mill up to the top of the dry feed silos (at an elevation of approximately 80 feet). The air flow entering the dry feed silos is vented to the forced draft (FD) fan and treated in the downstream RCS. The instantaneous flow rate of this pulse of air (over several seconds) will be damped in the freeboard tank volume and associated duct volume in route to the FD fan system. The FD fan system incorporates a gravimetric damper that normally includes ambient air flow into the process system (above that required to maintain negative pressure in the vented process equipment). As this pulse of air reaches the FD fan, the damper will close off to maintain negative pressure in vent system. When the melter is not operating, the FD fan outlet flow bypasses the air heater and is directed into the APC system to route all vent flows into the RCS.

2.6 DRY FEED SILO

Three dry feed silos shall be sized for a total storage capacity of up to 7 days of dry feed material for the CMS™. The dense-phase pneumatic conveyor system shall transfer the feed material into the dry feed silos. The silos shall be maintained under negative pressure. Material shall be removed from the silos using metering screw conveyors and discharged into a transfer screw conveyor for transfer to a batch blending system.

2.7 GLASS ADDITIVE SILOS

The three glass additive silos shall be sized for storing a one month supply of each of three additives for blending with the feed material to the CMS™. Pneumatic transport systems on the delivery trucks shall transfer the glass additives into the three silos. Metering screw conveyors on the discharge of each silo shall control the additive feed rate based on a predetermined recipe for the dried feed material. The predetermined recipe will be based on the sampling results of the dry feed material. The additives shall be discharged into a transfer screw conveyor for transfer to a batch blending system.

2.8 BATCH BLENDER SYSTEM

A 65 cubic foot batch blender (4 ft by 8 ft) shall be used to mix and blend the dry feed material and glass-making additives. The blender shall use a continuous double ribbon design agitator. After the material is charged to the mixer and mixed, a pneumatic actuated slide gate is opened to discharge the material into the surge hopper for the L-valve metering screw. The blender shall be maintained under negative pressure.

2.9 L-VALVE METERING SCREW WEIGH FEED SYSTEM

A weigh hopper and metering screw shall be used to transfer the mixed material into the CMS™ reactor. The weigh hopper capacity shall be sized to hold 4 hours of feed material (65 cubic feet). The hopper shall be maintained under negative pressure.

3.0 VORTEC VITRIFICATION CYCLONE MELTING SYSTEM™ (CMS™)

The CMS™ operation monitors and controls the rate of the dry feed, preheated air, oxygen, natural gas fuel, and cooling water to produce a glass product in which the radionuclides and heavy metals in the feed become part of the glass structure and are immobilized. The equipment and instrumentation required for this process are described below. The glass product is discharged into a wet dragflight conveyor system. The off-gas from the CMS™ flows to the evaporative cooler, which is the first stage of the APC System.

The dry feed blended with glass additives shall be introduced at the top of the CMS™ reactor, along the centerline by means of an injector. The feed material rate shall be controlled using a volumetric feed screw and weigh scale. A small solids hopper sized to hold 4 hours of feed material shall be used to feed the volumetric screw. The screw operation shall be interlocked to a waste feed permissive signal.

The combustion air shall be preheated in an indirect natural gas-fired air heater. A variable speed centrifugal fan shall provide the air and a turbine meter shall measure the air flow rate. The intake air of the fan shall vent process equipment in the feed preparation area and maintain a negative pressure on the equipment. During emergency shutdown, this air shall by-pass the CMS™ and be vented to the downstream evaporative cooler.

A control valve and pressure regulator shall regulate the natural gas flow rate and a turbine meter shall monitor its flow rate. A fail-closed solenoid valve shall provide emergency shutdown of the natural gas flow.

The combustion air shall be enriched to 30% oxygen. The oxygen tank shall be sized for 7 days of operation. The oxygen vaporizer unit shall be sized for the maximum operation rate required. A fail-closed solenoid valve shall provide emergency shutdown of the oxygen flow.

Cooling water shall cool the CRV and the cyclone melter. The cooling water shall circulate from the cooling tower.

The CMS™ off-gas is discharged to the APC system. The CMS™ off-gas flow rate, oxygen (O_2) content, and carbon monoxide (CO) shall be monitored in the off-gas after the APC system. Particulate removed from the CMS™ off-gas in the baghouse (downstream) shall be recycled back to the cyclone melter. A screw conveyor shall transfer the material from the baghouse solids hopper to the cyclone melter. The operation of the screw conveyor shall interlock with the feed stream to the CMS™ process.

A power failure or a high gas temperature exiting from the evaporative cooler shall initiate an emergency shutdown event. Such an event shall be interlocked to trip the waste feed, shut-off the burners, and put the system in a safe shutdown mode. In this mode, the CMS™ is "bottled-up," meaning there is no gas flow through the system, to minimize heat loss allowing hot re-start if the event is resolved in a reasonable time period. Due to the low glass inventory, the system easily accommodates partial or total cool-down depending on what the situation requires. During normal operations, if a positive pressure measurement in the CMS™ separator is detected, the control system shall alert the operator to take appropriate action.

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4.0 VITRIFIED PRODUCT HANDLING SYSTEM

The glass product from the CMS™ process shall be discharged into a wet dragflight conveyor. The conveyor shall be sized for a 2,000 lb/hr glass production rate. The water in the dragflight conveyor shall cool the molten glass and provide a water seal that prevents process gas from being vented from the conveyor discharge. Steam generated from cooling the molten glass shall be vented through a condenser and the condensate returned to the conveyor system. The condenser shall be conservatively sized for the entire product cooling duty. The water level shall be maintained using a float level controller. A low water level or high temperature alarm shall trip waste feed. The cooling duty of the water shall be provided by circulating the water through a heat exchanger cooled with water from the cooling tower.

The drag flight conveyor shall convey the fritted glass into a shipping container located on a remotely operated conveyor system. A sampling system shall provide a composite sample of the glass product. A weigh scale intregal to the conveyor system shall indicate when the container is filled. When the container is filled, the dragflight shall temporarily stop. The filled container shall move down the conveyor and a remotely operated crane shall lift the lid of the shipping container into place on the filled container and the container shall then be conveyed out of the radioactive area. The container shall be stored until picked up for final disposal after analysis has verified the product meets requirements.

A clean shipping container shall be loaded onto the conveyor, an isolation door opened, and the new container positioned under the dragflight conveyor discharge. The conveyor will be equipped with screen flites to allow de-watering of the frit and the speed is adjusted to allow the residual heat in the glass to dry the frit material before it is transferred into the concrete container. After the new container is placed, the dragflight conveyor is restarted.

During an emergency shutdown event, the dragflight conveyor shall stop. The molten glass product will continue to flow for a period of time. The volume of glass product is estimated to be equivalent to 15 minutes of the steady-state feed rate (approximately 400 pounds). The quench tank is sized sufficiently to contain approximately twice this estimated volume. The cooling water supply for the quench dragflight conveyor shall continue by powering the cooling tower pump on the emergency power bus.

5.0 AIR POLLUTION CONTROL (APC) SYSTEM

The APC system consists of an evaporative cooler, baghouse, and a condenser/scrubber system. The off-gas from the APC system shall be controlled to less than 20 ppmv of SO_2 and NOx; less than 0.021 lb water/lb gas (79°F saturated gas); and an off-gas flow rate near 500 scfm that can be treated for radon gas removal by the downstream RCS equipment, which is provided from the Silos 1&2 Advanced Waste Retrieval (AWR) project. Appendix A provides a further detailed discussion regarding the off-gas flow rate to the RCS. The gas flow rate shall be measured downstream of the scrubber system prior to entering the RCS using a turbine meter. A high gas flow rate alarm shall alert the operators to take the appropriate action. Each unit operation in the APC system is described below.

There is an option included in the cost estimate that increases the off-gas flow rate and APC capacity to 1,000 scfm. This option would also include the addition of two carbon beds and approximate costs for expanding the RCS building size to house them. It is not expected that the ID fan size or in-situ gas sampling equipment will need to be modified.

5.1 EVAPORATIVE COOLER

The evaporative cooler shall cool the CMS™ off-gas from 2,400°F to 450°F by controlling the amount of water sprayed into the vessel. A separate water tank and pump system shall provide the cooling water utilizing atomizing air nozzles to provide a fine spray capability. The cooling water make-up is from the dryer screw condensate tank and from potable water. A back-flow preventer installed on the inlet of the tank and an air gap shall isolate the tank from the potable water supply. The water flow-rate, pressure, and off-gas temperature shall be measured and monitored. A high or low temperature, or low water pressure alarm shall interlock to trip the waste feed, shut-off the burners, and vent the combustion air fan flow downstream through the evaporative cooler. Emergency shutdown or a high temperature alarm shall activate the emergency water system. The emergency water system shall provide a 5 minute supply of cooling water using a pressurized tank system..

5.2 BAGHOUSE

The baghouse shall remove 99.5% of the solid particulate from the off-gas stream. A screw conveyor shall recycle the removed solids back to the cyclone melter in the CMS™ process. The baghouse bag material shall allow operation at a 450°F gas temperature. Insulation and heaters shall prevent condensation and moisture from accumulating in the baghouse filters and solids hopper.

5.3 CONDENSER/SCRUBBER SYSTEM

The off-gas from the baghouse shall be cooled and scrubbed in the condenser/scrubber system to meet the off-gas requirements for 20 ppm NOx and SO_2, and 0.021 lb water/lb gas. The scrubber system shall consist of a prequench unit followed by a three section scrubber. The prequench section shall saturate the gas with a mild caustic solution, and cool the gas to about 180°F. The off-gas shall be further cooled to near 100°F by recycling a high flow rate (approximately 100 gpm) of cooled water. The water circulated in the scrubber shall be cooled in a heat exchanger using cooling water from the cooling tower. (The pH of the scrubber liquid shall be controlled at or below 8.5 to minimize scrubbing CO_2 from the gas.)

The second scrubber section shall use sodium hypochlorite NaOCl to oxidize the NO gases to NO_2. The third stage shall scrub the NO_2 gases with NaOH. The alkaline stage shall be cooled by recycling chilled water. The water from this section shall be pumped through a water chiller to cool the off-gas to 75°F (0.021lb water/lb gas). A demister shall remove entrained water droplets.

5.4 BOOSTER FAN

The off-gas from the second scrubber shall discharge into an in-line variable speed centrifugal fan to control the gas pressure at approximately -2 inches w.c. pressure entering the RCS.

5.5 OFF-GAS MONITORING SYSTEM

The off-gas shall be monitored for O_2, CO, SO_2, NOx, and gas flow rate (acfm). The process shall be controlled to maintain the off-gas concentration of both SO_2 and NOx at or below 20 ppmv, and the gas flow rate near 500 scfm that can be treated for the removal of radon gas by the downstream RCS equipment. The monitored rates shall be transmitted to the Central Control System (CCS). The off-gas shall be ducted to the RCS.

6.0 WASTEWATER TREATMENT SYSTEM

The condensate from the scrubber system removal of NOx, SO_2, and heavy metals (lead, barium, and arsenic) from the off-gas will result in a small, 3 to 4 gpm, purge stream from the APC system that shall require treatment to remove soluble metals. The pH of the water shall be adjusted to 9.25 to precipitate any soluble lead and other heavy metals. The water shall be held in a clarifier tank to allow settling. The treated water shall be sparged with a 2 scfm air rate for 2 hours to remove any radon gas, which is vented to the RCS. The treated water shall be sampled and discharged to the AWWT.

A small peristaltic pump shall pump the solids underflow from the clarifier tank (heavy metal solids precipitant and any particulate) to the dryer screw during dryer screw operation. A solids underflow rate of 1 to 3 lb/hr is estimated, based on a 99.5% removal efficiency in the baghouse for particulate.

7.0 CENTRAL CONTROL SYSTEM (CCS)

A programmable logic controller (PLC) shall monitor and control the process variables for equipment operation. The instrumentation output shall be based on a 4 to 20 milliamp (ma) signal. The control system shall be based on a single PC-based work station using an Allen Bradley control system. The PLC logic diagrams and programming for equipment operation shall be prepared during the detailed design phase of the project. The control system and instrumentation operation shall be maintained during power outages using an uninterruptible power supply (UPS) battery system.

8.0 UTILITY SYSTEM

The plant utilities required include electric power, water, natural gas, oxygen, compressed air, cooling water, chilled water, emergency power, and caustic. The demand for each is described below. In addition, some consideration of equipment required for maintenance has been included in the design and cost estimate. Two equipment systems for the removal of residual materials in the process equipment prior to conducting maintenance activities shall be included; one for flushing and draining wet or slurried material, and one for removal of dry material from process equipment. The wet system shall include an 8,000 gallon stirred tank, peristaltic pump, and wet vacuum pump to handle liquids and slurries. The dry system shall include a large HEPA vacuum filtration system for dry materials that uses a 55 gallon drum to collect the dry residues. The material collected will be recycled back into the process after the maintenance activities are completed. This system will either have its own carbon filters for radon or the APC system will have means to accommodate the exhaust in order to route it to the RCS. Detailed maintenance activity requirements will be developed during the detailed design phase of the project in the preparation of maintenance and operating procedures.

The electric power demand shall be based on 125% of the load and a power factor of 0.8. The cost estimate shall include a step-down transformer to provide 3-phase 460 volt power to the site.

The potable water demand shall be based on a supply rate of 30 gpm. The plant process demand consists of the cooling tower make-up water at a maximum of about 20 gpm and the evaporative cooler water demand of 2 gpm.

A natural gas usage rate of 20 kscfh shall be provided to operate the dryer screw (10 kscfh) and the Vortec CMS™ reactor (4 kscfh).

An oxygen tank and vaporizer unit shall be supplied to provide oxygen for the Vortec CMS™ reactor. The unit shall be installed and rented from the oxygen manufacturer. The unit shall be sized to supply 20% over the maximum usage rate of 250 lb/hr.

The compressed air supply shall include an air dryer system, 100 gallon compressed air tank, and a 25 hp (100 acfm @ 90 psi) compressor equipped with water and air filtration.

The cooling water shall be supplied from a 15MM Btu/hr cooling tower. The tower shall be designed to provide cooling water at a temperature of 85°F. The operation shall require a 40 hp fan and 875 gpm cooling water recycle pump rate. Plate-plate type heat exchangers shall be used for the water to water heat exchangers in the wet dragflight conveyor and in the APC scrubber system. Steam vapor condenser heat exchangers shall be used for condensing the dryer steam condensate and wet dragflight steam condensers.

A small 0.5 MM Btu/hr water chiller system shall cool the scrubber system off-gas to a temperature of 75°F.

The caustic usage rate for the scrubber is approximately 17 gph at a 20% concentration. A 5,000 gallon storage tank shall provide for a 2 week operational supply of caustic. A metering pump shall circulate the caustic solution to the scrubber skid in order to supply a constant line pressure at the pH control valve.

A 1,500 gallon storage tank shall provide the sodium hypochlorite solution used for scrubbing the NOx gas. A low usage rate of less tan 1 gph is expected.

An emergency diesel generator rated at 1,000 KVA shall operate the APC system, cooling tower pump, the centrifugal fans (combustion air fan, booster fan, and ID fan), and supply compressed air for instrument operation in the event of power loss.

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PROCESS DESCRIPTION

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS^{TM})

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

FDF Vortec Commercial Scale CMS™

PROCESS DESCRIPTION
for the
Remediation of Silo 1 & 2 Residues
Using the Vortec Cyclone Melting System

1.0 INTRODUCTION

This document specifies the process description of the full-scale facility to process residue originating from the Silos 1 & 2 located at the U.S. Department of Energy's (DOE) Fernald Ohio Site. The annual operating schedule is 24 hours/day, 7 days/week, and with a 70% operational availability. The process description is presented by subsystem of the processing facility. These subsystems include the following:

- feed preparation system
- Vortec Vitrification Cyclone Melting System™ (CMS™)
- vitrified product handling system
- air pollution control system
- wastewater treatment system
- central control system
- utility system

The process equipment and flow diagram for the process facility is depicted in Drawing E-4200.808.002. Equipment data sheets for each major piece of equipment are included in Appendix B. The process equipment, tanks, and associated piping are shielded, as required, to reduce radiation exposure and vented to the radon control system (RCS) to maintain radon gas control.

2.0 FEED PREPARATION SYSTEM

The feed preparation system receives a slurry feed stream from the Transfer Tank Area (TTA) and prepares the feed for processing in the Vortec Vitrification System. An overview of the start-up and operation of the feed preparation system is discussed below.

The feed preparation system receives a slurry feed stream from the transfer tanks and de-waters, dries, provides storage of the dry feed, and mixes glass making additives for processing in the Vortec CMS™. Carbon steel is the material of construction for the feed preparation equipment, except for one stainless steel glass additive silo, since the pH of the slurry feed is near 8. The feed preparation equipment is designed to prepare a dry feed rate of 8,000 lb/hr from the dryer, operating 4 days per week and 8 hours per day. Using this basis results in a 1,600 lb/hr (24 hr/day, 7 days/wk) material rate which is approximately 40 percent over the CMS™ operating rate of 1155 lb/hr. The process description for each major piece of equipment in the feed preparation area is described in the remainder of this section.

2.1 SLURRY FEED TANK

The slurry feed material (10 to 30% solids at the dry basis feed rate of 5,900 LB/hr) is transferred from the Tank Transfer Area (TTA) to an 8,000 gallon stirred tank sized to receive 1 hour of the 10% solids slurry stream at a flow rate of approximately 120 gpm. The tank is vented to the RCS to maintain the tank under slight negative pressure. Slurry feed material is pumped via a peristaltic pump to two centrifuges operating in parallel.

2.2 CENTRIFUGES

Two 60 gpm centrifuges, one for each dryer screw, shall be used to de-water the feed material from the slurry feed tank to about 50 wt% solids content. Each centrifuge shall be located directly above one of the dryer screws. The de-watered solid feed from each centrifuge shall discharge into one of the dryer screws. The liquid from the centrifuge (centrate) is pumped back to the TTA using a peristaltic pump.

2.3 DRYER SCREW SYSTEM

Two dryer screws, operated in parallel (each with four 16 foot by 24 inch diameter screws), dry the feed material. The dryer screws are sized to reduce the water content of 16,000 lb/hr solids feed material from 50 wt% to 5 wt%. The dryer screws shall be operated 32 hours per week, therefore based on 168 total hours per week, provides a maximum average dry feed rate of 1600 lb/hr dry feed. A natural gas-fired heated oil system provides the 9 MM btu/hr heat duty to dry the feed material. The oil temperature is controlled between 600° and 620° F. The dried material is conveyed into the hammer mill.

The hot oil screws were selected for this application to minimize the air flow and dust generated from drying the feed. Treating the slurry feed directly in the CMS™ process would result in a very large APC and RCS gas loading (of approximately 4,000 acfm), resulting in approximately an 8 fold increase in the size of the RCS treatment capacity. In order to minimize the off-gas flow rate, the plant design dries the slurry feed material in the hot oil screws. Other drying equipment, e.g., hot air dryers, rotary kilns, or calciners, all would result in higher off-gas flow rates and increased dust generation and dust handling issues.

Hot oil dryer screws have been used in numerous applications including commonly used for drying fine particulate and clay-type materials. Although pure bentonite clay slurries are particularly difficult to dry because they coat and insulate the surface of the screw, in this application, most of the feed solids (approximately 95%) are a finely ground processed uranium ore (10 to 30 microns in size) and a small concentration (5 wt%) of Bento Grout™ is used as a grout material. The Bento Grout™ is not pure bentonite clay, but includes a large percentage (65%) of silica (SiO_2) that provides a base for the material. The effect of the presence of the Bento Grout™ is a concern, although at the low concentrations present, it is not an over-riding concern. The study performed to determine the settling rates of the feed material clearly indicate that the process uranium ore feed behaves as a "sandy" material, and not as the Bentogrout™ material which forms a liquid suspension layer. The high concentration of the uranium ore (60% silica) is expected to provide an abrasive environment to scour and clean the screw surface. In addition, the drying screws provide a self cleaning capability because of their intermeshing design which minimizes the buildup of clay on the screws.

However, due to the presence of the Bento Grout™, the design basis for the screws was conservatively set to allow for additional drying capacity above the required average feed rate of 1,152 lb/hr and also allow for increasing the available feed preparation weekly hours of operation (from 32 up to 168). These two factors represent up to a 6.3 fold increase in the available drying capacity above the average required feed rate. During the detailed design phase of the full-scale remediation project, it would be beneficial to perform additional testing of the drying processes and update the drying process design basis.

Two contingency plans are available to mitigate any potential affects of the Bento Grout™ material. The first alternative would modify the discharge ducting of the dryer screw to allow the periodic (e.g., monthly) scouring of any build-up of clay material off of the screws by processing a batch of pea gravel (or glass product) through the dryer screws into a separate bin. This scouring material would be stored and reused. This treatment has been utilized in past projects where hot oil dryer screws have been used for drying sticky clay materials. This treatment would be scheduled when feed material was not being processed.

The second alternative to treat the feed material would minimize the amount of Bento Grout™ material separated by the centrifuge (which is more difficult to separate from the slurry feed) and use micro-filtration equipment to separate the Bento Grout™ from the centrifuge centrate. The micro-filtration equipment would be similar to that proposed for the TTA facility where it was used to filter wastewater from the Silos 1 and 2 retrieval process prior to discharge to the Fernald Site Advanced Waste Water Treatment (AWWT) system. After separating the Bento Grout™ from the centrate, the 600 cubic meters (wet basis) of separated Bento Grout™ material would be further solidified using the glass-making additives prior to processing the material in a batch mode through the hot oil dryer screws.

A water cooled condenser condenses water evaporated from the feed. A cooling tower provides the water for the condenser. The condensate from the dryer feed is drained into a 30,000 gallon tank and used as cooling water in the evaporative cooler. Any excess water will be pumped to the scrubber system sumps for metals treatment and radon degassification, and then discharged to the AWWT. The condensate tank is vented to the RCS to maintain negative pressure in the dryer screw.

The dryer screws are each driven by a 25 hp hydraulic motor. The hydraulic drive pressure is operated at its normal set point. The drives are equipped with a reverse jog feature that allows the screw to be reversed to unjam it. If the jog feature does not reverse the screws and clear the obstruction, the hydraulic oil pressure may be increased to clear the obstruction on a supervised basis.

During an emergency shutdown event, the dryer screw and heating oil will stop. The steam evaporation from the wet feed in the inlet to the dryer screw will continue for a period of time. The cooling water supply for the steam condenser will continue by powering the cooling tower pump on the emergency power bus. If the shutdown includes the CMS™, the FD fan outlet flow bypasses the air heater and is directed into the APC system to route all vent flows into the RCS.

2.4 Hammer Mill

A hammer mill sized for 10,000 lb/hr feed reduces the dry feed material from the dryer screw to a mesh size of under 35 (~600μ). The dry material passes into a surge hopper for transfer into the dry feed storage silos by the dense-phase pneumatic conveyor. The mill is maintained under negative pressure.

2.5 Pneumatic Conveyor System

A dense-phase pneumatic conveyor system is used to transfer the material from the hammer mill into the dry feed silos. The system includes a surge hopper to receive the material from the hammer mill and lift the material approximately 80 feet up to the top of the dry feed silos. The system transfers material into one of the three silos approximately every 6 minutes. The material is sampled using a pneumatic sampling device as the material is transferred. The material samples are analyzed to verify the glass-additive recipe required to treat the feed material. The surge hopper is maintained under negative pressure.

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The pneumatic system provides the most reliable and maintenance-free transfer system available to elevate the dried feed material to the dry feed silos. The pneumatic system avoids the uses of very long screw, belt, or bucket elevator systems. A 200 scfm pulse of compressed air is used to transfer a batch of the feed material from the hammer mill up to the top of the dry feed silos (at an elevation of approximately 80 feet). The air flow entering the dry feed silos is vented to the forced draft (FD) fan and treated in the downstream RCS. The instantaneous flow rate of this pulse of air (over several seconds) will be damped in the freeboard tank volume and associated duct volume in route to the FD fan system. The FD fan system incorporates a gravometric damper that normally includes ambient air flow into the process system (above that required to maintain negative pressure in the vented process equipment). As this pulse of air reaches the FD fan, the damper will close off to maintain negative pressure in vent system. When the melter is not operating, the FD fan outlet flow bypasses the air heater and is directed into the APC system to route all vent flows into the RCS.

2.6 DRY FEED SILO

Three dry feed silos shall be sized for a total storage capacity of up to 7 days of dry feed material for the CMS™. The dense-phase pneumatic conveyor system transfers the feed material into the dry feed silos. The silos are maintained under negative pressure. Material is removed from the silos using metering screw conveyors and discharged into a transfer screw conveyor for transfer to a batch blending system.

2.7 GLASS ADDITIVE SILOS

The three glass additive silos are sized for storing a one month supply of each of three additives for blending with the feed material to the CMS™. Pneumatic transport systems on the delivery trucks transfers the glass additives into the three silos. Metering screw conveyors on the discharge of each silo shall control the additive feed rate based on a predetermined recipe for the dried feed material. The predetermined recipe will be based on the sampling results of the dry feed material. The additives are discharged into a transfer screw conveyor for transfer to a batch blending system.

2.8 BATCH BLENDER SYSTEM

A 65 cubic foot batch blender (4 ft by 8 ft) is used to mix and blend the dry feed material and glass-making additives. The blender uses a continuous double ribbon design agitator. After the material is charged to the mixer and mixed, a pneumatic actuated slide gate is opened to discharge the material into the surge hopper for the L-valve metering screw. The blender is maintained under negative pressure.

2.9 L-VALVE METERING SCREW WEIGH FEED SYSTEM

A weigh hopper and metering screw is used to transfer the mixed material into the CMS™ reactor. The weigh hopper capacity is sized to hold 4 hours of feed material (65 cubic feet). The hopper is maintained under negative pressure.

3.0 VORTEC VITRIFICATION CYCLONE MELTING SYSTEM™ (CMS™)

The CMS™ operation monitors and controls the rate of the dry feed, preheated combustion air, oxygen, natural gas fuel, and cooling water to produce a glass product in which the radionuclides and heavy metals in the feed become immobilized as part of the glass structure. The glass product discharges into a wet dragflight conveyor system (Section 4.0) and the off-gas flows to the evaporative cooler in the Air Pollution Control (APC) system (Section 5.0). The equipment and instrumentation required for the CMS™ process are described below.

The dry feed blend with glass additives is introduced at the top of the CMS™ reactor, along the centerline by means of an injector. The feed material rate is controlled using a volumetric feed screw and weigh scale. A small solids hopper, sized to hold 4 hours of feed material, is used to feed the volumetric screw. The screw operation is interlocked to a waste feed permissive signal.

The combustion off-gas flow rate, oxygen (O_2) content, and carbon monoxide (CO) shall be monitored in the off-gas after the APC system.

The combustion air is preheated in a natural gas-fired air heater. A variable speed, centrifugal fan provides the air and a turbine meter measures the air flow rate. The intake air of the fan vents process equipment in the feed preparation area and maintains a negative pressure on the equipment. During emergency shutdown, this air by-passes the CMS™, and vents to the downstream evaporative cooler.

A control valve and pressure regulator regulates the natural gas flow rate, and a turbine meter monitors its flow. A fail-closed solenoid valve permits emergency shutdown of the natural gas flow.

The combustion air is enriched to 30% oxygen. The oxygen tank is sized for 7 days of operation. A fail-closed solenoid valve permits emergency shutdown of the oxygen flow.

Water from a cooling tower cools the CMS™. Solids removed from the baghouse (downstream) are recycled back to the cyclone melter. A screw conveyor transfers the material from the baghouse solids hopper to the cyclone melter. The operation of the screw conveyor interlocks with the feed stream to the CMS™ process.

An overview of the combustion air fan operation for the CMS™, and emergency shutdown operations are discussed below.

Combustion Air Fan Operation

The design, utilizing the combustion fan intake air for continuously venting the feed preparation equipment, whether or not the CMS™ is operating, is achieved as follows:

1. While the CMS™ system is not operating, the combustion air fan by-pass valve routes the vent air downstream from the CMS™ system to the evaporative cooler.
2. When the CMS™ is ready to start, the combustion air fan is set at an rpm such that the stack off-gas flow, with the by-pass valve 100% open, is approximately 450 acfm. The by-pass control valve is set to control the stack flow at the 450 acfm, i.e., 100% open. (The air flow rate is initially set below the 500 acfm limit in order to allow a margin for controlling the by-pass valve.)
3. As the combustion air fan speed is increased slowly (ramped up), increasing the stack gas flow, the by-pass control valve will close the valve to restrict air being by-passed downstream from the CMS™ and force the air to be routed through the natural gas-fired air heater to the CMS™.

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4. When higher combustion air rates are required in the CMS™ (e.g., when the by-pass control valve is approximately 5% open), the set point for the off-gas flow can be raised to near 500 acfm, and the fan speed increased accordingly.

Emergency Shutdown Operation

A power failure or a high gas temperature exiting from the evaporative cooler initiates an emergency shutdown event. Such an event interlocks to trip the waste feed, shut-off the burners, and put the system in a safe shutdown mode. The system will be programmed to provide the following actions during an emergency shutdown event:

1. The combustion air fan by-pass control valve will fail to open, by-pass the combustion air (and vent air) downstream from the CMS™ process.
2. The emergency generator will auto-start to power the system.
3. The emergency cooling water in the evaporative cooler will remain activated until the emergency power generator comes on-line.
4. During power failures, the combustion air and ID fan will auto-set to the fan speed required to provide a 500 acfm gas flow rate out of the stack.

4.0 VITRIFIED PRODUCT HANDLING SYSTEM

The glass product from the CMS™ process discharges into a wet dragflight conveyor. The water in the dragflight conveyor cools the molten glass product and provides a water seal that prevents process gas from being vented out of the conveyor discharge. The cooling duty of the water is provided by circulating the water through a heat exchanger cooled with water from the cooling tower. Steam generated from cooling the molten glass is condensed in a condenser and the water returned to the conveyor. The water level is maintained using a float level controller. A low water level or high temperature alarm shall trip waste feed.

The dragflight conveyor directs the fritted glass into a shipping container located on a remotely operated conveyor system. A sampling system collects and prepares a composite sample of the glass product. The conveyor is equipped with screen flites to allow de-watering of the frit and the speed is adjusted to allow the residual heat in the glass to dry the frit material before it is transferred into the concrete container. A weigh scale, as part of the conveyor system indicates when the container is filled.

When the container is filled, the dragflight conveyor temporarily stops. The filled container moves down the conveyor and a remotely operated crane lifts the lid of the shipping container into place on the filled container. The filled container with a lid is conveyed out of the radioactive area and stored. After analysis has verified the product meets requirements, it is picked up for final disposal. A clean shipping container is loaded onto the conveyor, the isolation door is opened, and the new container is positioned under the dragflight conveyor discharge. An absorbent agent is placed into the bottom of the container to control any free liquids that drain from the fritted glass. After the new container is placed, the dragflight conveyor is restarted.

The dragflight conveyor will stop during an emergency shutdown event. The molten glass product continues to flow for a period of time. The volume of glass product is estimated to be equivalent to 15 minutes of the steady-state feed rate (approximately 400 pounds). The quench tank is sized sufficiently to contain approximately twice this estimated volume. The cooling water supply for the quench dragflight conveyor continues by powering the cooling tower pump on the emergency power bus.

An alternative design of discharging the molten glass directly into the concrete cask could be accommodated; however, it is Vortec's opinion that such a system;

1. results in a minimal savings in number of cask containers required (on the order of 200)
2. would require a different product sampling methodology
3. is more expensive because it does not readily lend itself to recycling any out-of-spec materials
4. requires a separate restricted staging area to allow the casks to cool.

5.0 AIR POLLUTION CONTROL (APC) SYSTEM

The APC system consists of an evaporative cooler, baghouse, and a condenser/scrubber system. The off-gas from the APC system is controlled to maintain less than 20 ppmv of SO_2 and NOx; less than 0.021 LB water/LB gas (79°F saturated gas); and an off-gas flow rate near 500 scfm that can be treated for radon by the downstream Radon Control System (RCS) equipment, which is provided from the Silos 1&2 Advanced Waste Retrieval (AWR) project. Appendix A provides a further detailed discussion regarding the off-gas flow rate to the RCS. A high flow alarm interlocks to the waste feed permissive. Each unit operation in the APC system is described below.

There is an option included in the cost estimate that increases the off-gas flow rate and APC capacity to 1,000 scfm. This option would also include the addition of two carbon beds and approximate costs for expanding the RCS building size to house them. It is not expected that the ID fan size or in-situ gas sampling equipment will need to be modified.

5.1 EVAPORATIVE COOLER

The evaporative cooler cools the off-gas from the CMS™ from 2,400°F to 450°F by evaporating the water sprayed into the vessel. A separate water tank and pump system using air atomized nozzles supplies a fine spray capability. The water is derived from the dryer screw condensate and potable water. A back-flow preventer on the inlet of the tank isolates the tank from the potable water supply. The water flow-rate, off-gas temperature, and pressure are measured and monitored. A high or low temperature, or low water pressure alarm interlocks to trip the waste feed, shut-off the burners, and route the combustion air downstream from the CMS™ process to the evaporative cooler. During emergency shutdown or a high temperature alarm, the emergency water system will activate. The emergency water system delivers a 5 minute supply of cooling water using a pressurized tank system.

The unit's normal operating off-gas temperature would be between 400 and 450°F. As discussed above, during the CMS™ start-up, the excess vent air will route from the combustion air fan to the evaporative cooler until the CMS™ combustion air rates are maximized. As the vent air is reduced, the tempering of water by the evaporative cooler will increase.

5.2 BAGHOUSE

The baghouse removes 99.5% of the solid particulate from the off-gas stream using a PF-84 felt bag. Approximately 15 scfm of pulsation air is required to pulse clean the bags every 12 seconds. The particulate is collected in a pyramid shaped hopper and a screw conveyor transfers the removed solids back to the cyclone melter in the CMS™ process. The baghouse felt bag material allows operation at a 450°F gas temperature. Insulation and heaters on the solids hopper keeps condensation and moisture from accumulating in the baghouse filters and solids hopper.

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5.3 CONDENSER/SCRUBBER SYSTEM

The off-gas from the baghouse is cooled and scrubbed in the condenser/scrubber system to meet the off-gas requirements for 20 ppm NOx and SO_2, and 0.021 lb water/lb gas. The scrubber system consists of a prequench unit followed by a horizontal three section scrubber. The pre-quench section saturates the gas with a mild caustic solution, cooling the gas to approximately 180°F. The off-gas is further cooled to near 100°F by recycling cooled water at a high flow rate (approximately 100 gpm) in the first section of the scrubber. The water circulated in the scrubber is cooled in a heat exchanger using cooling water from the cooling tower. (The pH of the scrubber liquid is controlled at or below 8.5 to minimize scrubbing CO_2 from the gas.)

The second scrubber section uses Sodium Hypochlorite (NaOCl) to oxidize the NO gases to NO_2. The third stage scrubs the NO_2 gases with NaOH. Recycled chilled water cools the alkaline stage using a water chiller to cool the off-gas to 75°F (0.021 lb water/lb gas). Two demister units remove entrained water droplets.

5.4 BOOSTER FAN

The off-gas from the second scrubber discharges into a variable speed centrifugal fan to control the gas pressure at approximately 2 inches w.c. pressure entering the RCS.

5.5 OFF-GAS MONITORING SYSTEM

The off-gas is monitored for O_2, CO, SO_2, NOx, and gas flow rate (acfm). The process requirements are to maintain the off-gas concentration of both SO_2 and NOx at or below 20 ppmv, and the gas flow rate near 500 scfm that can be treated for radon by the downstream RCS equipment. The monitored rates are transmitted to the Central Control System (CCS). The off-gas is ducted to the RCS.

6.0 WASTEWATER TREATMENT SYSTEM

The condensate from the scrubber systems removal of NOx, SO_2, and heavy metals (lead, barium, and arsenic) from the off-gas results in a small 3 to 4 gpm purge stream from the APC requiring treatment to remove soluble metals. The pH of the water in the metal treatment skid is adjusted to 9.25 to precipitate any soluble lead and other heavy metals and the water is held in clarifier tank to allow settling. The treated water is then sparged with a 2 scfm air rate for 2 hours to remove radon gas which is vented to the RCS; sampled and discharged to the AWWT.

The solids underflow from the clarifier tank (heavy metal solids precipitated and any particulate) is periodically pumped via a small peristaltic pump to the dryer screw during dryer screw operation. A solids underflow rate of 1 to 3 LB/hr is estimated, based on a 99.5% solids particulate removal efficiency in the baghouse.

7.0 CENTRAL CONTROL SYSTEM (CCS)

Programmable logic controller (PLC) monitor and control the process variables for equipment operation. The instrumentation output is based on a 4 to 20 milliamp (ma) signal. The control system is based on a single PC-based work station using an Allen-Bradley control system. The PLC logic diagrams and programming for equipment operation are included in the detailed design phase of the project. The control system and instrumentation operation are maintained during power outages using an uninterruptible power supply (UPS) battery system.

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8.0 UTILITY SYSTEM AND MAINTENANCE EQUIPMENT

The plant utilities required include electric power, water, natural gas, oxygen, compressed air, cooling water, chilled water, emergency power, and caustic. The demand for each are described below.

In addition, some consideration of equipment required for maintenance has been included in the design and cost estimate. Two equipment systems for the removal of residual materials in the process equipment prior to conducting maintenance activities have been included; one for flushing and draining wet or slurried material, and one for removal of dry material from process equipment. The wet system includes an 8,000 gallon stirred tank, peristaltic pump, and wet vacuum pump to handle liquids and slurries. The dry system includes a large HEPA vacuum filtration system for dry materials that uses a 55 gallon drum to collect the dry residues. The material collected will be recycled back into the process after the maintenance activities are completed. Detailed maintenance activity requirements will be developed during the detailed design phase of the project in the preparation of maintenance and operating procedures.

The electric power demand is based on 125% of the load and a power factor of 0.8. The cost estimate shall include a step-down transformer to provide 3-phase 460 volt power to the site.

The potable water demand is based on a supply rate of 30 gpm. The plant process demand consists of the cooling tower make-up water at a maximum of approximately 20 gpm and the evaporative cooler and pre-quench water demand of up to 5 gpm. Other intermittent site uses include water for bathrooms, showers, and maintenance.

A natural gas usage rate of 20 kscfh is necessary to operate the dryer screw (10 kscfh) and Vortec CMS™ reactor (4 kscfh).

An oxygen tank and vaporizer unit supplies oxygen for the Vortec CMS™ reactor. The unit is installed and rented from the oxygen manufacturer. The unit is sized to supply 20% over the maximum usage rate of 250 LB/hr.

The compressed air supply includes an air dryer system, 100 gallon compressed air tank, and a 25 hp (100 acfm @ 90 psi) compressor equipped with water and air filtration.

The cooling water is supplied from a 15 MM Btu/hr cooling tower. The tower is designed to cool water to 85°F. The tower operation requires a 40 hp fan and 875 gpm cooling water recycle pump rate. Plate-plate heat exchangers are used for the water-water heat exchangers in the wet dragflight conveyor and in the APC scrubber system. Steam vapor condenser heat exchangers are used for condensing in the dryer screw and wet dragflight steam condensers.

A small 0.5 MM Btu/hr water chiller system cools the scrubber system off-gas to a temperature of 75°F.

The caustic usage rate for the scrubber is approximately 17 gph at a 20% caustic concentration. A 5,000 gallon storage tank provides a 2 week operation supply of caustic. A metering pump circulates the caustic solution to the scrubber skid in order to supply a constant line pressure at the pH control valve.

A 1,500 gallon storage tank stores the sodium hypochlorite solution used for scrubbing the NOx gas. A low usage rate of less than 1 gph is expected.

An emergency diesel generator rated at 500 KVA operates the cooling tower pump and the centrifugal fans (combustion air fan, booster fan, and ID fan) and supplies compressed air for operation in the event of power loss.

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EQUIPMENT LIST

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS™)

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

FDF Vortec Commercial Scale CMS™
Equipment List

Equipment No.	Equipment Description	Comment
P-1	Holding tank transfer pump, peristaltic pump transfers the stirred slurry from the holding tank to the centrifuges	Pump may be used to provide washdown water for cleanout of conveyors, screws, etc.
P-2	TTA transfer pump, peristaltic pump will pump the decanted supernate from the centrifuges back to the TTA	Pump may be used to provide washdown water for cleanout of conveyors, screws, etc.
CENT-1, CENT-2	Centrifuges, used to dewater TTA slurry from its initial 10-30 % solids content to 50% solids content.	Centrifuge solids output directed into dryer screws, liquid output pumped back to TTA, off-gas routed to FD fan
DS-1, DS-2	Dryer screws, these are used to dry the feed from 50% water to 5% water	One motor drives a reducer/drive unit which drives the multiple screws.
HTR-1	Thermal fluid heater, used to heat Dowtherm Q fluid for circulation through the dryer screws	Have MSDS for Dowtherm Q
BM-1	Hammer mill/shredder, used to de-agglomerate the dry feed after exiting the dryer screw prior to storage in dry feed storage hopper	Device breaks up material which has agglomerated in the dryer screws
PCS-1	Dense phase pneumatic conveying system	Systems transports output of ball mill to dry feed storage hoppers
DF-1, DF-2 DF-3	Dry feed storage hoppers	Storage of approximately one week of feed
DA-1	Dry additives hopper for CaO	Material of construction is carbon steel Have MSDS for CaO
DA-2	Dry additives hopper for NaOH	Material of construction is carbon steel Have MSDS for NaOH
DA-3	Dry additives hopper for LiOH	Material of construction is stainless steel Have MSDS for LiOH
MS-1, MS-2, MS-3	Metering devices for feeding out of dry feed hoppers DF-1, DF-2, and DF-3	Material of construction is carbon steel
MS-4	Metering devices for feeding out of CaO bin DA-4	Material of construction is carbon steel
MS-5	Metering devices for feeding out of NaOH bin DA-5	Material of construction is carbon steel
MS-6	Metering devices for feeding out of LiOH bin DA-6	Material of construction is stainless steel
TSC-1	Transfer screw transports dry feed to blender	Material of construction is carbon steel

FDF Vortec Commercial Scale CMS™ Equipment List

TSC-2	Transfer screw transports dry additives to TSC-3	Material of construction is stainless steel
TSC-3	Transfer screw transports dry additives to blender	Material of construction is stainless steel
TSC-4	Transfer screw transports bag-house solids to CMS recycle input hopper	Material of construction is stainless steel
FB-1	Feed blender unit accepts batch of dry feed and dry additives and blends them	Material of construction is stainless steel One batch of feed is 65 ft^3
SB-1	Surge bin acts provides four hours of feed storage	Material of construction is stainless steel
SC-1	L-valve/Transfer screw with loss-in-weight feeder	Provides volumetric metering with gravimetric validation of throughput
FAN-1	Forced draft combustion air fan	Primary combustion air fan
FAN-2	Induced draft fan	Booster fan
P-3	Water hold-up tank pump	Provides water to the evaporative cooler
P-4A P-4B	Nox scrubber sump recycle pump & backup	Cycles water through chiller CH-1 and the Nox scrubber
P-5A P-5B	Sox scrubber sump to WTS pump & backup	Cycles water through HTX-2 and a sidestream on to the WTS
P-6A P-6B	Urea injection pump & backup	Injects urea into the Nox scrubber/CH-1 stream
P-7A P-7B	Caustic storage tank pump	Provides caustic to the cooling tower sump
P-8	Cooling tower pump	Provides pump head for all cooling tower users
P-9	Drag-flite ash conveyor recycle pump	Recycles water through the condenser loop back to the quench tank
P-10A P-10B	Oxidizing zone recycle pump	Recycles water through the oxidizing zone
P-11	Maintenance washdown return water pump	Returns collected washdown water back to the TTA
HTX-1	Dryer screw vapor heat exchanger	Condenses the steam vapor coming off the dryer screws. Condensate goes to the hold-up tank (TK-1)
HTX-2	Sox scrubber sump water heat exchanger	Cools the Sox scrubber sump stream
HTX-3	Drag-flite quench water heat exchanger	Cools the drag-flite quench water

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FDF Vortec Commercial Scale CMS™
Equipment List

HTX-4	Drag-flite vapor heat exchanger	Condenses the steam vapor off the drag-flite conveyor
EC-1	Evaporative cooler	Cools the CMS off-gas stream prior to bag-house
BH-1	Bag-house	Removes solids from off-gas stream Removed solids recycled to CMS
S-1	Sox scrubber	Sump is integral to the scrubber unit
S-2	Nox scrubber	Sump is integral to the scrubber unit
SMP-1	Sox scrubber sump	Collect effluent from S-1
SMP-2	Nox scrubber sump	Collect effluent from S-2
CH-1	Nox scrubber chiller	Carries the cooling load for the scrubber unit
WT-1	Water treatment system package	Stand alone water treatment system deals with the Nox/Sox water streams
FSS-1	Dry feed sampling system	System takes samples of the dry feed for laboratory analysis
SS-1	Water sampling system	System takes samples of the output of the water treatment package for laboratory analysis
SS-2	Glass product sampling system	System takes samples the glass product output for laboratory analysis
TK-1	TTA slurry hold-up tank with integral in-tank mixer	8000 gallon tank, mixer keeps solids suspended to preclude settling
TK-2	Dryer screw heat exchanger condensate holdup tank	30,000 gallon tank
TK-3	Radon degasification tank	1000 gallon tank
TK-4	Hypochlorate storage tank	1500 gallon tank
TK-5	Caustic storage tank	5000 gallon tank
TK-6	Washdown water return tank with integral in-tank mixer	Collects and holds washdown return water prior to being pumped back to the TTA
TK-7	Emergency water tank	Tank is pressurized and aligned with fail-open valve. On power failure it provides emergency quench water to the Evaporative Cooler (EC-1) until diesel generator comes on line and returns pumps to service

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FDF Vortec Commercial Scale CMS™
Equipment List

QT-1	Ash quench tank and conveyor system	Glass frit migrates from the CMS into the quench tank and is subsequently conveyed to the product output bin
CT-1	Cooling tower package	Carries the cooling load for all water cooled components
C-1, C-2	Powered roller conveyors, used to transport the glass product bin into and out of the product discharge area.	Conveyor control system to index the bin to the various stages
VAC-1	HEPA filtered vacuum for evacuating dry feed components	Unit is mobile with 150 ft. of hose
AC-1	Air compressor package	Provides clean, dry, compressed air to various usage points
O2-1	Oxygen enrichment system	Provides oxygen for enrichment of the combustion air
JC-1	Jib crane	Remotely operated jib crane de-lids and re-lids the glass product storage bins as they enter and exit the glass product handling area
DG-1	Diesel generator set	Provides emergency backup power to essential equipment during power outage

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INSTRUMENT LIST

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS^{TM})

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

FOSTER WHEELER ENVIRONMENTAL CORPORATION

FDF Vortec Commercial Scale CMS™ Instrument List

Related Equipment Description	Related Eq. No.	Instrument/ Vendor	Comment	Instrument Function	Signal
BAG FILTER	BF-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
HAMMER MILL	BM-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
GLASS FRIT WEIGHT	C-1/2	WT-			
CENTRIFUGE 1	CEN-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
CENTRIFUGE 2	CEN-2	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
CHILLER	CH-1	TE-WEED		TEMP ELEMENT	100 OHM
CHILLER	CH-1	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
CYCLONE MELTER	CMS	TE-WEED		TEMP ELEMENT	100 OHM
CYCLONE MELTER	CMS	TE-WEED		TEMP ELEMENT	100 OHM
CYCLONE MELTER	CMS	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
CYCLONE MELTER	CMS	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
COOLING TOWER	CT-1	LSL-B/W		LEVEL SWITCH	CONTACT
COOLING TOWER	CT-1	LT-MAGNETROL	ULTRASONIC	LEVEL TRANSMITTER	ANALOG
GLASS SILO 1	DA-1	LSH-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
GLASS SILO 1	DA-1	LSL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
GLASS SILO 1	DA-1	LSLL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
GLASS SILO 2	DA-2	LSH-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
GLASS SILO 2	DA-2	LSL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
GLASS SILO 2	DA-2	LSLL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT

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FOSTER WHEELER ENVIRONMENTAL CORPORATION

FDF Vortec Commercial Scale CMS™
Instrument List

GLASS SILO 3	DA-3	LSH-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
GLASS SILO 3	DA-3	LSL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
GLASS SILO 3	DA-3	LSLL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 1	DF-1	LSH-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 1	DF-1	LSL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 1	DF-1	LSLL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 1	DF-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
DRY FEED HOPPER 2	DF-2	LSH-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 2	DF-2	LSL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 2	DF-2	LSLL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 2	DF-2	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
DRY FEED HOPPER 3	DF-3	LSH-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 3	DF-3	LSL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 3	DF-3	LSLL-MAGNETROL	VIBRATION	LEVEL SWITCH	CONTACT
DRY FEED HOPPER 3	DF-3	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
EVAP COOLER	EC-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
FD FAN	FAN-1	FE-FCI		FLOW ELEMENT	N/A

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FDF Vortec Commercial Scale CMS™
Instrument List

FD FAN	FAN-1	FT-FCI		FLOW TRANSMITTER	ANALOG
ID BOOSTER FAN	FAN-2	AE-ROSEMOUNT		ANALYSIS	N/A
ID BOOSTER FAN	FAN-2	AT-ROSEMOUNT		ANALYSIS	ANALOG
ID BOOSTER FAN	FAN-2	AT-ROSEMOUNT		ANALYSIS	ANALOG
ID BOOSTER FAN	FAN-2	FE-FCI		FLOW ELEMENT	N/A
ID BOOSTER FAN	FAN-2	FT-FCI		FLOW TRANSMITTER	ANALOG
ID BOOSTER FAN	FAN-2	TE-WEED		TEMP ELEMENT	100 OHM
ID BOOSTER FAN	FAN-2	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
HOT OIL HEATER	HTR-1	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
OIL HEATER 1 INLET	HTR-1	TE-WEED		TEMP ELEMENT	100 OHM
OIL HEATER 1 OUTLET	HTR-1	TE-WEED		TEMP ELEMENT	100 OHM
OIL HEATER INLET	HTR-1	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
OIL HEATER OUTLET	HTR-1	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
OIL HEATERS EX COOL	HTX-1	TE-WEED		TEMP ELEMENT	100 OHM
OIL HEATERS EX COOL	HTX-1	TE-WEED		TEMP ELEMENT	100 OHM
OIL HEATER EXHAUST COOL	HTX-1	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
OIL HEATER EXHAUST COOL	HTX-1	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
HOLDING TANK PUMP 1	P-1	PI-ASHCROFT		PRESSURE IND	N/A
HOLDING TANK PUMP 1	P-1	PT-ROSEMOUNT		PRESSURE TRANS	ANALOG
SUMP 2 RECYCLE PUMP	P-10A	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
SUMP 2 RECYCLE PUMP	P-10A/B	TE-WEED		TEMP ELEMENT	100 OHM
SUMP 2 RECYCLE PUMP	P-10A/B	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
SUMP 2 RECYCLE PUMP	P-10B	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
WASHDOWN WATER RETURN PUMP	P-11	PI-ASHCROFT		PRESSURE IND	N/A

FDF Vortec Commercial Scale CMS™
Instrument List

WASHDOWN WATER RETURN PUMP	P-11	PT-ROSEMOUNT		PRESSURE TRANS	ANALOG
RETURN PUMP 2	P-2	PI-ASHCROFT		PRESSURE IND	N/A
RETURN PUMP 2	P-2	PT-ROSEMOUNT		PRESSURE TRANS	ANALOG
HOLD-UP TNK PUMP	P-3	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
SUMP 1 RECYCLE PUMP	P-4A	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
SUMP 1 RECYCLE PUMP	P-4A/B	TE-WEED		TEMP ELEMENT	100 OHM
SUMP 1 RECYCLE PUMP	P-4A/B	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
SUMP 1 RECYCLE PUMP	P-4B	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
SO2 SCRUBBER PUMP	P-5A	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
SO2 SCRUBBER PUMP	P-5A, 5B	TE-WEED		TEMP ELEMENT	100 OHM
SO2 SCRUBBER PUMP	P-5A, 5B	TE-WEED		TEMP ELEMENT	100 OHM
SO2 SCRUBBER PUMP	P-5A, 5B	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
SO2 SCRUBBER PUMP	P-5A, 5B	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
SO2 SCRUBBER PUMP	P-5B	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
NaOCl TANK PUMP	P-6A	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
NaOCl TANK PUMP	P-6B	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
NaOH TANK PUMP	P-7A	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
NaOH TANK PUMP	P-7B	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
COOLING TOWER PUMP	P-8	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG

FDF Vortec Commercial Scale CMS™ Instrument List

QUENCH TANK RECYCLE PUMP	P-9	PIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
QUENCH TANK RECYCLE PUMP	P-9	TE-WEED		TEMP ELEMENT	100 OHM
QUENCH TANK RECYCLE PUMP	P-9	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
QUENCH TANK	QT-1	LSL-B/W		LEVEL SWITCH	CONTACT
QUENCH TANK	QT-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
QUENCH TANK	QT-1	TE-WEED		TEMP ELEMENT	100 OHM
QUENCH TANK	QT-1	TT-MSYSTEMS		TEMP TRANSMITTER	ANALOG
SO2 SCRUBBER	S-1	LSH-B/W		LEVEL SWITCH	CONTACT
SO2 SCRUBBER	S-1	LSL-B/W		LEVEL SWITCH	CONTACT
SO2 SCRUBBER	S-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
NO2 SCRUBBER	S-2	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
BELT SCALE	SB-1	LSH-MAGNETROL		LEVEL SWITCH	CONTACT
BELT SCALE	SB-1	LSL-MAGNETROL		LEVEL SWITCH	CONTACT
BELT SCALE	SB-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
BELT SCALE	SB-1	WT-			
SUMP TANK 1	SMP-1	LSH-B/W		LEVEL SWITCH	CONTACT
SUMP TANK 1	SMP-1	LSL-B/W		LEVEL SWITCH	CONTACT
SUMP TANK 2	SMP-2	LSH-B/W		LEVEL SWITCH	CONTACT
SUMP TANK 2	SMP-2	LSL-B/W		LEVEL SWITCH	CONTACT
HOLDING TANK	TK-1	LSH-B/W		LEVEL SWITCH	CONTACT
HOLDING TANK	TK-1	LSL-B/W		LEVEL SWITCH	CONTACT
HOLDING TANK	TK-1	LT-SAAB	RADAR	LEVEL TRANSMITTER	ANALOG
HOLDING TANK	TK-1	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG

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FDF Vortec Commercial Scale CMS™
Instrument List

DRYER SCREW CONDENSATE HOLD-UP TANK	TK-2	LSH-B/W		LEVEL SWITCH	CONTACT
DRYER SCREW CONDENSATE HOLD-UP TANK	TK-2	LSL-B/W		LEVEL SWITCH	CONTACT
DRYER SCREW CONDENSATE HOLD-UP TANK	TK-2	LT-MAGNETROL	ULTRASONIC	LEVEL TRANSMITTER	ANALOG
DRYER SCREW CONDENSATE HOLD-UP TANK	TK-2	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
RADON DEGASIFICATION TANK	TK-3	LSL-B/W		LEVEL SWITCH	CONTACT
RADON DEGASIFICATION TANK	TK-3	LT-MAGNETROL	ULTRASONIC	LEVEL TRANSMITTER	ANALOG
RADON DEGASIFICATION TANK	TK-3	PDIT-ROSEMOUNT		PRESSURE TRANS	ANALOG
NaOCl STORAGE TANK	TK-4	LSL-B/W		LEVEL SWITCH	CONTACT
NaOCl STORAGE TANK	TK-4	LT-MAGNETROL	ULTRASONIC	LEVEL TRANSMITTER	ANALOG
NaOH STORAGE TANK	TK-5	LSL-MAGNETROL	SPHERICAL THERMAL DISPERSION	LEVEL SWITCH	CONTACT
NaOH STORAGE TANK	TK-5	LT-ENRAGH	DISPLACEMENT FLOAT	LEVEL INTERFACE	ANALOG
WASHDOWN WATER RETURN TANK	TK-6	LSH-B/W		LEVEL SWITCH	CONTACT
WASHDOWN WATER RETURN TANK	TK-6	LSL-B/W		LEVEL SWITCH	CONTACT
WASHDOWN WATER RETURN TANK	TK-6	LT-SAAB		LEVEL TRANSMITTER	ANALOG
PLC		PLC			
OUTPUTS FROM PLC CONTACT			26		
OUTPUTS FROM PLC ANALOG			12		
INPUTS TO PLC ANALOG			49		
INPUTS TO PLC CONTACT			26		

ENVIRONMENTAL REVIEW

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS™)

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

FDF Vortec Commercial Scale CMS™

ENVIRONMENTAL REVIEW
for the
Remediation of Silo 1 & 2 Residues
Using the Vortec Cyclone Melting System

The silos residue is classified as a byproduct material as defined under Section 11(e)(2) of the Atomic Energy Act (AEA) of 1954, as amended. Under this classification, it is excluded from regulation as solid or hazardous waste under the Resource Conservation and Recovery Act (RCRA). However, the material must be treated such that it no longer exhibits a hazardous characteristic. The following Environmental Review presents a summary of all key state and federal regulations or Applicable or Relevant and Appropriate Requirements (ARARs) concerning effluent discharges during the construction and operation of the Vortec Commercial Scale Cyclone Melting System (CMS™) treatment facility. These ARARs will be incorporated into the design and operation to ensure environmental compliance of the project. A discussion of the CMS™ by subsystem and how the design, construction, or operation will comply with the required ARARs follows.

Prior to siting the facility, a site evaluation will be performed to verify that there will be no impacts to nearby floodplains or wetlands from the construction or operation of this facility and ensure that a NEPA evaluation has been performed and documented. Additionally, a Best Management Practices program will be developed including management of stormwater run-on and run-off and spill prevention control and countermeasures plans.

The Vortec Commercial Scale CMS™ facility consists of seven (7) subsystems that will be necessary for the remediation of the Silo 1 and 2 Residues. These seven subsystems are the:

- Feed Preparation System,
- Vortec Vitrification Cyclone Melting System (CMS™),
- Vitrified Product Handling System,
- Air Pollution Control System,
- Wastewater Treatment System,
- Central Control System, and
- Utility System.

Environmental compliance will be implemented throughout the design of these subsystems and throughout the operation of the facility in a variety of ways including:

- utilizing good engineering practices, such as;
  - recycling effluent streams back to the system,
  - use of a collection tank for the dryer condensate which is used for recycling as make-up water for the evaporative cooler,
  - use of negative pressure to control radon gas and particulate generation, and
  - use of a dense phase pneumatic conveyance to minimize system air consumption;
- utilizing best management practices;
- development and implementation of training programs, such as
  - H&S program, including PPE rationale and usage,
  - Chemical Hygiene Plan,

- CONOPS,
- project specific procedures and guidelines,
- Radiation Protection Program,
- Hazard Communication Program, and
- Contingency Plan; and

- proper monitoring and sampling to ensure compliance.

The feed preparation system receives a slurry feed stream from the Transfer Tank Area (TTA), dewaters, dries, provides storage of the dry feed for processing and dry additives, and mixes glass making additives for the CMS™. This system consists of a slurry feed tank, two (2) centrifuges, two (2) dryer screw systems, a hammer mill, a pneumatic conveyor system, three (3) dry feed silos, three (3) glass additive silos, a batch blender system, and the L-valve metering screw weigh feed system. The process equipment, tanks, and associated piping will be shielded to reduce radiation exposure and vented, as required, to maintain radon gas control. Due to the quantity of material stored in the dry feed storage tanks and the corresponding radiation levels, the tanks are isolated and shielded to minimize the potential exposure to radiation. All appropriate system components that contains the feed material will be maintained under negative pressure to control radiation exposure and particulate generation. All of the appropriate system components are vented with the air stream recycled to the CMS™; additionally the water removed during centrifuging is recycled to the TTA, creating a closed system. The steam generated during the drying process in the dryer screws is collected, vented through a heat exchanger and stored in a hold-up tank for use in the Air Pollution Control (APC) system. Additionally, the use of a dense phase pneumatic conveyance system to convey the dried material to the dry feed storage tanks reduces the air consumption required to transfer material in the system.

The CMS™ operation monitors and controls the rate of the dry feed, preheated combustion air, oxygen, natural gas fuel, and cooling water to produce a glass product in which the radionuclides and heavy metals in the feed become immobilized as part of the glass structure. The off-gas from the CMS™ flows to the APC system.

The vitrified product handling system consists of a quench tank with drag conveyor, an output sampling system, and a storage bin conveyance system. The solids effluent or glass output of the CMS™ is transferred to the quench tank for cooling. This tank is vented to the CMS™ system and steam generated from the cooling of the molten glass process is vented through a heat exchanger, cooled by water from a cooling tower, with the condensate returned to the quench tank. Additionally, the water in the quench tank is cooled in the same manner, through a heat exchanger and cooled with water from the cooling tower, and returned to the quench tank. This design again creates a closed system for the effluents. The quenched glass is sampled as the material is loaded into the storage/shipping containers located on a remotely operated conveyor system. The containers are catalogued and temporarily stored, in a properly managed storage area, pending analysis of the sample. Once the analytical results are received and deemed acceptable, the shipping container is sealed and released for shipment.

The APC system consists of an evaporative cooler, a baghouse, a condensate/scrubber system, and an off-gas monitoring system. The off-gas from the CMS™ recuperator is cooled by an evaporative cooler. The cooled off-gas is then passed through the baghouse, where the solids removed are recycled back to the CMS™. The filtered off-gas from the baghouse is then processed through the condenser/scrubber system to meet the acceptance criteria for the radon control system (RCS). The off-gas from the condenser/scrubber system will be controlled and monitored for flow rate, oxygen (O_2), carbon monoxide (CO), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) to ensure compliance with the RCS acceptance criteria. The RCS, which is operated by others, will treat the off-gas with carbon beds for radon removal and perform isokinetic sampling of the effluent for permit compliance. The water effluent from the APC is routed to a radon degasifier tank, for radon removal with the vent recycled to the CMS™, followed by treatment with a water treatment package and sampled prior to discharge at the advanced wastewater treatment (AWWT) system. This system design allows for recycling or pretreatment and sampling of all effluents from the process to ensure protection of human health and the environment.

The wastewater treatment system will remove soluble metals from the purge steam from the APC system prior to discharge at the AWWT system. The treated water will be sampled prior to discharge to the AWWT system to ensure compliance with the waste acceptance criteria (WAC).

The central control system (CCS) and the utility system provide programmable logic controllers (PLC) for monitoring and controlling the equipment operation and the utilities necessary to operate the treatment facility. The CCS will be maintained during power outages utilizing an uninterrupted power supply (UPS) battery system to ensure continued operation and controls of the process and materials. This completes the system that is designed to comply with the regulatory requirements and ensure protection of the human health of the workers, surrounding public, and the environment.

The following Environmental Review presents a summary of the key state and federal regulations or Applicable or Relevant and Appropriate Requirements (ARARs) concerning air emissions and water management that will be incorporated into the design and operation of the treatment system to ensure environmental compliance of the project. This table includes ARARs established under federal and state environmental laws, and to be considered (TBC) criteria which were determined to be necessary to ensure protection of human health and the environment.

Regulation	Primary Requirements
40 CFR 50 – National Primary and Secondary Ambient Air Quality Standards	• Sulfur Oxides – Primary standard – Level of annual standard for is 0.030 ppm – Level of 24-hr standard is 0.14 ppm • Sulfur Oxides – Secondary standard – 3-hr standard is 0.5 ppm • PM_{10} – Primary standard – 150 $\mu g/m^3$ 24-hr concentration • Particulate matter – Primary and secondary – 15 $\mu g/m^3$ annual arithmetic mean concentration – 65 $\mu g/m^3$ 24-hr average measured as $PM_{2.5}$ • Carbon Monoxide – Primary standard – 9 ppm for an 8-hr average – 35 ppm for a 1-hr average • Ozone – Primary and secondary standards – 0.12 ppm (235 $\mu g/m^3$) for 1-hr standard – 0.08 ppm for 8-hr standard • Nitrogen Dioxide – Primary and secondary standards – 0.053 ppm annual arithmetic mean • Lead – Primary and secondary standards – 1.5 $\mu g/m^3$ maximum arithmetic mean averaged over a calendar year

Regulation	Primary Requirements
40 CFR 122 – NPDES	• Create sampling point source for storm water run-off • Sample discharge resulting from storm event >0.1-in. and at least 72-hrs from the previous storm event
40 CFR 125 Subpart K – Criteria and Standards for BMPs	• BMP programs developed in accordance with good engineering practices • Include Spill Prevention Control and Countermeasure (SPCC) Plans • BMP Program submitted as part of permit application
40 CFR 61 Subpart Q – National Emission Standards for Radon Emissions from DOE Facilities	• No source shall emit more than 20 pCi/m^2-s of radon-222 as an average for the entire source, into the air
40 CFR 61 Subpart H – National Emission Standards for Emissions of Radionuclides Other Than Radon from DOE Facilities	• No source shall emit radionuclides that would cause any member of the public to receive an effective dose equivalent greater than 10 mrem/yr. Excluding Rn-222 and its respective decay products.
40 CFR 63 Subpart EEE – National Emission Standards for Hazardous Air Pollutants from Hazardous Waste Combustors	• Provide Notification of Intent to Comply
DOE Order 5400.5 – Radiation Protection of the Public and the Environment	• Implement applicable radiation protection standards and to consider and adopt, as appropriate, recommendations by authoritative organizations • Operate facilities so that radiation exposures to the public, and environment are within the limits established

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REGULATORY REVIEW

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS™)

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

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FOSTER WHEELER ENVIRONMENTAL CORPORATION

FDF Vortec Commercial Scale CMS™

REGULATORY REVIEW
for the
Remediation of Silo 1 & 2 Residues
Using the Vortec Cyclone Melting System

The silos residue is classified as a byproduct material as defined under Section 11(e)(2) of the Atomic Energy Act (AEA) of 1954, as amended. Under this classification, it is excluded from regulation as solid or hazardous waste under the Resource Conservation and Recovery Act (RCRA). Furthermore, since the silo residue is not regulated by RCRA, a RCRA Part B permit will not be required; however, a new source air quality construction permit or a Title V operating permit may be required since the facility produces a new point source for the RCS system to treat and release to the atmosphere and the air heater associated with the CMS is vented to the atmosphere. However input to existing site-wide permits and NEPA documentation will be required to construct and operate the facility including:

- Input for stormwater discharge,
- Input to NPDES permit for the AWWT, and
- Air emissions information for NESHAP.

This table includes ARARs established under federal and state environmental laws, applicable U.S. Department of Energy (DOE) Orders, and to be considered (TBC) criteria not included in the environmental review, which were determined to be necessary to be incorporated into the design, construction, and operation to ensure protection of human health and the environment.

Regulation	Primary Requirements
10 CFR 835 – Occupational Radiation Protection	• Compliance with FDF RPP. • Exposure limits for workers and the public in the controlled area. • Monitoring required • Written authorization required to enter radiological areas • Postings and package labeling required • Monitoring records maintained • Radiation safety training required • Incorporate ALARA into design • Accident and emergency plans • Written procedures • Selection of cognizant individuals with appropriate education, training, and skills • Internal audits of program and implementation
10 CFR 820 – Procedural Rules for DOE Nuclear Activites	• PAAA implementation on DOE facilities • Enforcement policy and process • Liability and penalties

Regulation	Primary Requirements

10 CFR 830.120 – Quality Assurance Requirements	• Written QA Program that addresses: – Personnel training and qualifications; – Quality improvement; – Documents and records; – Controlled word processes including procedures, item control, equipment calibrations and maintenance; – Design control program including basis, standards interface, changes, verification/validation; – Procurement control program; – Inspection and acceptance testing; and – Management and independent assessments.
10 CFR 1022 – Compliance with Floodplain/Wetlands Environmental Review Requirements	• Perform evaluation to verify no floodplain/wetlands impacts
40 CFR 125 Subpart K – Criteria and Standards for Best Management Practices (BMP)	• BMP programs developed in accordance with good engineering practices • Include Spill Prevention Control and Countermeasure (SPCC) Plans • BMP Program submitted as part of permit application
40 CFR 191 Subpart A – Environmental Standards for Management and Storage	• Materials stored to provide reasonable assurance that the combined annual dose equivalent to public does not exceed 25 mRem to the whole body and 75 mRem to any critical organ
40 CFR 192 – Health and Environmental Protection Standards for Uranium and Thorium Mill Taillings	• Control of residual radioactive materials and their listed constituents are designed to : – Be effective for up to 1000 years – Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere comply with established limits – Provide reasonable assurance of conformance with groundwater protection provisions • A groundwater monitoring plan shall be implemented
40 CFR 264 Subpart B – General Facility Standards OAC 3745-54-13 – 16	• FDF facility security meets this security requirement • Inspections of facility at scheduled intervals required • Training of personnel required for specific duties by trained person. Training to include at a minimum: – Response to emergencies – Shutdown of operations – Use, inspection, repair, and replacement of emergency and monitoring equipment • Maintain Job descriptions and training records • Must not be located within 200 ft. of fault

Regulation	Primary Requirements
40 CFR 264 Subpart C – Preparedness and	• Designed, constructed, maintained, and operated to minimize possibility of fire, explosion, or other unplanned release of hazardous waste

Prevention	• Must have: – Internal communication or alarm system to provide emergency instruction – Telephone – Portable fire extinguishers and fire control equipment – Water at volume sufficient for fire suppression
40 CFR 264 Subpart D – Contingency Plan and Emergency Preparedness	• Must have Contingency Plan on site and submitted to all emergency response providers and local hospitals
40 CFR 264 Subpart I – Use and Management of Containers OAC 3745-55-71 – 78	• Containers must be in good condition • Containers must be compatible with waste • Containers must be inspected regularly • Container storage areas must have a containment system
40 CFR 264 Subpart J – Tank Systems OAC 3745-55-91 – 96	• Secondary containment for tanks must include one of the following devices: – A liner, – A vault, – A double-walled tank, or – An equivalent approved device • Schedule of tank inspections established and followed
40 CFR 264 Subpart X – Miscellaneous Units	• Must be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and environment
40 CFR 268 Subpart D – Treatment Standards	• All hazardous constituents in treated residue must be at or below values in the CFR table; or • Hazardous constituents in extract of the treatment residue must be at or below values found in table
40 CFR 370 – Hazardous Chemical Reporting: Community Right-to-Know	• Maintain MSDSs on site • Submit Tier I form annually • Submit inventory form to the commission, committee, and fire department with jurisdiction • Allow on-site inspections for fire department
10 CFR 1021.0 – NEPA Implementation	• Perform NEPA evaluation and documentation
40 CFR 1500-1508 – NEPA	• Perform NEPA evaluation and documentation

Regulation	Primary Requirements
29 CFR 1910.132-140 – OSHA	• PPE shall be provided • Assess workplace and determine hazards and necessary PPE • Communicate PPE selection rationale to affected employees

	• Train employees to use PPE properly and document training • Establish written procedures for proper PPE use • Appropriate sanitation facilities shall be provided • Proper signage
29 CFR 1910.1200 – Hazard Communication	• Have hazard communication program • Have proper labeling and warnings • Have MSDSs on site for employee access • Provide employee information and training regarding job hazards
29 CFR 1940.1450 – Chemical Hygiene Plan	• Establish Chemical Hygiene Plan which is: – Capable of protecting employees from health hazards – Capable of keeping exposures below specified limits – Readily available to employees • Provide employees information and training • Provide employees with medical consultation and medical exams
29 CFR 1960 – Safety and Health Program	• Establish and utilize a Safety and Health Program to ensure a safe and healthful working conditions
DOE Notice 441.4 – Extension of DOE Notice 441.1, Radiological Protection for DOE Activites	• Extends DOE N441.1 until in full compliance with 10 CFR 835
DOE Notice 441.1 – Radiological Protection for DOE Activites	• Establish adminstrative dose limits. • Posting requirements.
DOE Policy 450.2A – Identifying, Implementing and complying with Environmental, Safety and Health Requirements	• Identify, implement, and comply with ES&H requirements so that work is performed in a manner that ensures adequate protection of workers and the public.
DOE Order 5400.5 – Radiation Protection of the Public and the Environment	• Implement applicable radiation protection standards and to consider and adopt, as appropriate, recommendations by authoritative organizations • Operate facilities so that radiation exposures to the public, and the environment are within the limits established
DOE Order 5480.4 – Environmental Protection, Safety, and Health Protection Standards	• Implement the requirements established for the application of the mandatory ES&H standards • Utilize the listed reference ES&H standards
DOE Order 5480.19 – Conduct of Operations Requirements for DOE Facilities	• Implement the requirements for developing directives, plans and procedures relating to conduct of operations • Assure use of consistent and auditable requirements, standards, and procedures

Regulation	**Primary Requirements**
DOE Order 5484.1 – Environmental Protection, Safety, and Health Protection Information Reporting Requirements	• Implement the established requirements and procedures for the investigation of occurrences having environmental protection, safety, or health protection significance • Perform the established monitoring of environmental protection, safety, or

	health protection issues
DOE Order 5820.2A – Radioactive Waste Management	• Implement the established policies, guidelines and minimum requirements to ensure the proper management of radioactive and mixed waste
DOE Order 6430.1A – General Design Criteria	• Incorporate the established general design criteria into the design of the facility

ANALYSIS OF RADON REMOVAL EFFICIENCY AND ASSOCIATED AIRFLOWS for the Remediation of Silo 1 & 2 Residues Using the Vortec Cyclone Melting System

The offgas flow rate given in the Proof-of-Principle conceptual design for the FDF Vortec commercial Scale Cyclone Melting System (CMS) is 570 cfm. This value exceeds the flow rate of 500 cfm given in the Interface Design Basis document 40720-DC-0001[1]. However, a study indicates that there is sufficient flexibility and conservatism in the planned Radon Control System (RCS) associated with the Accelerated Waste Retrieval (AWR) project to accommodate the additional 14% flow, and that using that flexibility is less costly than providing for additional radon treatment. The limits established for radon releases to the environment defined in the AWR RFP are still met.

An assessment of the effect on the 570 cfm offgas flow rate can be made using the equation for radon absorption given by Langner[2], i.e.,

$$C_o = C_i \exp(-\lambda KM/f)$$

Where

λ = the decay constant for radon-222, or 1.258E-4/minute

K = the absorption coefficient of activated carbon for radon (L/g)

M = the mass of dry carbon (g), and

f = the rate of airflow through the column (L/minute).

This equation was applied using K = 6 (the value defined in the design criteria for the AWR[3]), four beds, each containing 40,000 pounds of carbon, and two different airflows. The calculations were done to determine the difference in outlet radon concentrations that would be caused by the proposed increased flow from the CMS. The first airflow consisted of 500cfm from the Transfer Tank Area (TTA) plus the 500 cfm specified in the IDB. C_o/C_i for this airflow was found to be 0.144. The second airflow consisted of the same 500 cfm from the TTA plus 570 cfm from the CMS. C_o/C_i for the second airflow was found to be 0.163, an increase in the outlet concentration of 13.5%.

This increase may be accommodated in several ways to save the cost of adding additional radon control equipment.

First, based on the FWENC submittal regarding the proposed AWR, the RCS will reduce radon concentrations under the most unfavorable meteorological conditions to 55% of the limit specified in that RFP. A 13.5% increase in radon concentration will cause the that percentage to be increased to 62%, a value still less than the limit by margin enough to maintain most of the original operational flexibility.

Second, the airflow from the TTA may be reduced from the 500 cfm assumed, by 70 or more cfm to make up for the 70 cfm excess from the CMS. During the AWR and until the waste has been transferred to the TTA a substantial airflow will be required to reduce the radon concentration (and consequently the external dose rate) in the silo headspaces. However, the TTA head spaces will be shielded and the maintenance of a high velocity through these tanks is not needed to keep the dose rate down. Therefore, the flow from the TTA can be reduced without detriment, and the minor effect of the 70 cfm excess from the CMS can be completely mitigated.

Finally, Langner[2] indicates that the absorption coefficients (K) determined experimentally are more than double the value used in the RCS design criteria, provided that the air be cooled prior to its entry into the carbon beds. Cooling of this air is planned for the AWR project so actual emissions could be as much as 700% lower than determined using K = 6. This reduction will more than make up for the 13.5% increase that would be caused by the 70 cfm excess flow proposed.

In summary, the flexibility and conservatism in the existing design and operational concepts of the RCS can accommodate the proposed excess offgas flow rate without jeopardizing the protection of the employees, the public, or the environment. The cost of providing added radon controls is thereby obviated.

[1]Proof of Principle Interface Design Basis, Fluor Daniel Fernald, 40720-DC-0001, September 29, 1998

[2]Langner, G.H. Jr., "Controlling Radon Emissions with Activated Carbon Columns: Phase II Results", Rust Geotech/DOE Grand Junction Projects Office, Grand Junction, Colorado, August 8, 1996.

[3]Accelerated Waste Retrieval Project Technical Requirements Document, TRD-40710-RP-001, Appendix F, Radon Control System, Phase I, May 26, 1998.

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SAFETY REVIEW

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS™)

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

000166

FOSTER WHEELER ENVIRONMENTAL CORPORATION

FDF Vortec Commercial Scale CMS™

SAFETY REVIEW
for the
Remediation of Silo 1 & 2 Residues
Using the Vortec Cyclone Melting System

The safety review for the Vortec project is segregated into the two separate phases of work, construction and operation. These two phases are further segregated into the various specific tasks to be performed within each phase and each task examined for health and safety concerns to be addressed during the project design, construction, and implementation.

The construction phase consists of the following tasks:

- Excavation
- Pour slab
- Pour walls, ceiling (or use prefabricated slabs)
- Install studs, trusses and metal frame/roof
- Install equipment
  - Holding Tanks
  - Centrifuges
  - Vitrifier
  - Others
- Install infrastructure (wiring, HVAC)
- Test equipment

The operation phase consists of the following tasks:

- **Process Material**
  - Material slurried to the holding tank
  - Dewater in centrifuges
  - Dry in hot oil screw
  - Transfer to hammer mill
  - Pulverize to obtain desired particle size
  - Transfer to dry feed hopper via pneumatic conveyor system
  - Collect sample for analysis
  - Store 95% dry material
  - Transfer by metering screw to feed blender unit
  - Blend feed with glass additives
  - Vitrify
  - Pour into quench tank
  - Collect sample for analysis

- **Cask**
  - Install lifting fixture to lid
  - Transfer by conveyor and lift lid
  - Transfer to filling station

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- **Containerize Material**
  - Fill cask using dragflight conveyor
  - Transfer cask to station and place lid on cask
  - Transfer cask to clean area and remove lifting fixture
  - Secure cask lid
  - Survey cask and decontaminate if necessary
  - Ship cask to storage or disposal site

- **Waste streams**
  - Collect and return centrate water to TTA
  - Process off-gas and vent air

During the construction phase, there are no radiological concerns; however, there are a number of non-rad concerns to address during this phase of the project. These concerns are listed in Table 1. Radiological safety issues associated with Vortec operations can be divided into three main areas.

First, the potential for particulate airborne exposure from the waste should it be exposed to the workplace and become airborne, especially after drying. Thorium-230 is one of the waste products that will present the highest degree of hazard, but radium and other radionuclides are present and add to the potential for exposure.

Second, the exposure to radon gas, which is being generated continuously wherever radium-226 is present. Radon is a gas, and therefore, it is highly mobile. Once out of the solid matrix in which it is formed, it will diffuse through the air spaces in any process vessel and then travel along the ventilation flow paths.

Third, direct exposure to gamma radiation. The vast majority of the gamma radiation is generated by the radon daughters lead-214 and bismuth-214. These radionuclides are formed when radon decays, and therefore, will be found where radon is present.

The dynamics of the relationship between radium, radon, and the daughters affects the magnitude and location where exposure potential is high.

- Exposure to particulates is primarily a concern wherever there is solid waste present. Unventilated spaces where radon is present is a secondary concern. The continued presence of radon in an area allows time for the daughters to build up in concentration. They generally adhere to dust or other particles in air shortly after they are formed.
- Exposure to radon is a concern when radon diffuses out of the matrix where it is formed, e.g., wet or dry waste and is not carried away by the ventilation system.
- Direct exposure to radiation is a concern wherever radon is allowed to accumulate for more than an hour or so. The primary place for this is in the waste-anytime except after vigorous drying, i.e., in the hot oil screws or the CMS™, where the radon is driven off. The loss is soon made up however, by a new generation of radon after a day or two. A second concern occurs along the ventilation ductwork which carries the radon. Daughters are generated in the airstream and may plate out on the walls of the ducts. Although they decay rapidly (half lives less than 20 minutes) the decaying radionuclides are replaced by newly generated ones.

Gamma radiation from the radon daughters is energetic and requires substantial shielding.
Requirements for radiation protection can be defined by tracing the flow of waste through the process and accounting for the whereabouts of the radon and radon daughters.

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Slurry Feed Holding Tank

The Slurry Feed Holding Tank will normally be filled with material transferred from the TTA. The composition is expected to be up to 30% solids that contain radium, radon, and radon daughters in equilibrium. The predominant dose will be from the radon daughters. Dose rates just outside of the tank will exceed 100 mrem/hr. Therefore, the room containing the tank will be considered to be a high radiation area, and protected by locked doors. A small fraction of the radon, estimated to be about 1%, will be released and carried off to the FD fan. This will cause some plating out of radon daughters on the inside of the ductwork. However, the doses will be no more than 1 mrem/hr one foot from the duct. Contamination in the slurry feed holding tank room could occur if there were leaks. Provision will be made to collect any leakage, and clean-up afterward.

Maintenance for this and other pieces of equipment which hold large quantities of the waste will need to be carefully planned, to include emptying of the contained waste, and/or the use of local shielding.

Holding Tank Transfer Pump

The holding tank transfer pump moves the 30% slurry from the holding tank to the centrifuges. It only contains about two pounds of material, and the lines have a nominal diameter of 2". Therefore there is little radioactive material in the room and dose rates should not exceed 5 mrem/hr one foot from the pump. Since pumps are high maintenance items and have a tendency to leak, provision will be made to collect water from leakage or which might be released during maintenance, and clean up the wetted surfaces to prevent drying and the resultant generation of airborne activity.

TTA Transfer Pump

The TTA transfer pump moves the water from the centrifuges back to the TTA. The water will contain a small percentage (estimated to by 0-2%) of the original solids, so the dose rate near the pump will be no more than 0.5 mrem/hr. The potential for leakage, or spillage during maintenance will be addressed by providing for collection and clean-up.

Centrifuges

Each centrifuge may contain up to 360 pounds of radioactive material. The input enters with about 30% solids and leaves at about 50% solids. The dose rate adjacent to the centrifuge will be in the 30 to 40 mrem/hr range. Since the radioactive material will be contained in the equipment and any airborne activity vented to the forced draft fan, other radiation protection considerations will be limited to the collection and cleanup of leakage, or spills during maintenance.

Dryer Screws

The input to the dryer screws will be a slurry with 50% solids. Nearly all of the radon and the associated radon daughters which entered the system with the feed will still be intimately mixed with these solids. The output from the screws will be a solid mixture containing only 5% moisture. Because of the heat and mixing action, most of the radon will escape to the FD fans. The radon daughters, which accompanied the radon in the input, will remain in the solid mixture and generate enough gamma radiation to give a dose rate one foot from the screws of about 100 mrem/hr. This will be close enough to the definition of a high radiation area that the area will be locked with controlled access.

Contamination will be controlled through the system containment, and airborne radioactivity will be controlled by venting to the vitrification system. Leakage or loss of water during maintenance will only be important near the inlet end of the screws. Maintenance requiring opening of the outlet end will require protection from airborne activity as the now dry material can be easily suspended and inhaled.

Hammer Mill

The material entering the hammer mill will be 95% dry and subjected to vigorous mechanical agitation. Suspension of solid dust particles will occur and tend to contaminate the ductwork. High levels of airborne radioactivity will be encountered if the hammer mill has to be opened up for maintenance. The dose rate adjacent to the hammer mill (one foot away) will be about 40 mrem/hr. Since there is less radon remaining after drying of the material in the hot oil screws, fewer new radon daughters are produced in the short time that it takes for the material to pass through the (radon-less) part of the hot oil screws and the hammer mill. Daughters already in the mixture decay rapidly as soon as the radon (which replenishes them) has been driven off. Therefore, the dose rate from the ground up solids will be decreasing with time as the material passes through the hammer mill and is conveyed to the Dry Feed Storage Hoppers.

Pneumatic Conveying System

Material will be accumulated in the pneumatic conveying system for about a half hour. That time, added to the time the material spent in the hot oil screws (after the radon was driven off) and the hammer mill (another half hour) will allow the radon daughters to decay and the dose rate adjacent to the feed hopper will be reduced to about 10 mrem/hr. The potential for airborne radioactivity inside of the system will remain high since dry powder is being transferred. It will be important to keep the system effectively sealed, and to protect the workers if this system has to be opened up for maintenance.

Dry Feed Storage Hoppers

The dry feed storage hoppers will contain the dried material for about a week, i.e., material will be collected for about two days, sampled, and stored for a few days awaiting analysis, and emptied in about two more days. Although the radon, which was transferred into the system with the waste, will have been removed by the hot oil screws, the nominal one week of storage will allow it to ingrow again to about 82% of the original concentration. This will cause (1) the dose rates to increase, because the radon daughters will also ingrow, and (2) the release of a significant fraction of radon into the headspace (estimated to be 10%) by diffusion through the granular solid.

The dose rate from a single hopper may run as high as 550 mrem/hr. With three hoppers in the same room the dose rates could approach 1 rem/hr. These dose rates are significant, and will require the area to be controlled as a high radiation area. The facility is designed so that entry into the dry feed hopper room is very seldom, if ever, required. It follows that there is a need for a high degree of containment of the solids contained therein, to avoid spills that could necessitate entry. The resultant potential for airborne activity would further require consideration during any required maintenance.

Since fairly high rates of radon release (estimated to be 10%) are expected, contamination of the duct internals will also be high. However, dose rates in the vicinity of the ductwork will still be less than 1 mrem/hr.

Metering Devices

The dry feed hopper metering screws are six inches in diameter, and are expected to be half full of the same material that is in the hoppers. Since the amount of material in a metering screw is small compared to that elsewhere in the room, i.e., the three hoppers, the dose rate represents an insignificant addition. The same considerations apply, however, if maintenance has to be done.

Maintenance for this and other pieces of equipment which hold large quantities of the waste will need to be carefully planned, to include emptying of the contained waste, and/or the use of local shielding. The metering screws used for glass additives have no radiological significance.

Transfer Screw

The transfer screw in the dry feed hopper room, like the metering screws, contributes little (due to its volume) to the area dose rate - that is already high. The need for containment of the solid material remains very high. The transfer screw passes out of the dry feed hopper room, and would produce a local dose of about 20 mrem/hr at one foot. However, the major source of exposure will be the Feed Blender Unit, which will contain approximately 4500 pounds of the radioactive waste material.

The transfer screws used for glass additives have no radiological significance.

Feed Blender Unit

The Feed Blender Unit mixes about 4500 pounds of waste with 1800 pounds of chemicals. This dilutes the radionuclides, and the mixing allows some of the radon to escape. The residence time for the waste material in the blender is just short of four hours, so the radon daughters that are not replenished have time to decay. If radon was not released, the dose rate would be over 250 mrem/hr 1 foot from the side of the blender. However, it is likely that the dose rate will decrease, i.e., when some of the radon is released and the corresponding daughters decay. Nevertheless, the dose rate is still likely to exceed 100 mrem/hr, thus requiring the Feed Blender Unit room be considered a high radiation area. The potential for high concentrations of airborne radioactivity exists if there is leakage of air, and when the system has to be opened for maintenance.

Maintenance for this and other pieces of equipment which hold large quantities of the waste will need to be carefully planned, to include emptying of the contained waste, and/or the use of local shielding.

Surge Bin

The Surge Bin has the same volume as the Feed Blender Unit and contains the same material. Since it is a little more compact, the expected dose rate is larger, by about 20%. Therefore, the surge bin room will need to be managed as a high radiation area too. Since the waste is a dry powder, airborne radioactivity will be a problem if there are leaks and during maintenance.

L-valve/Transfer Screw

The L-valve transfer screw moves material from the Surge Bin to the CRV Reactor. The dose rate from the screw is insignificant in comparison with the adjacent surge bin. Leaks from and maintenance of the screw present the same problems as would result from Surge Bin maintenance.

Forced Draft Combustion Air Fan

The Forced Draft Fan pulls a vacuum on the entire processing system, except the off-gas from the CRV reactor and the subsequent off-gas treatment system. As such, all of the radon released from the various processes, and any entrained particulate will be in the air-stream that is moved through it. Deposition of particulates (which could include thorium-230 and lead-210) and the few radon daughters produced by the decay of radon during transit will be highest on the fan and fan housing. The dose rate adjacent to the fan is expected to be no more than 10 mrem/hr. However, the accumulation of dry particulates will make opening of the fan housing and any maintenance inside difficult. There would be a high potential for the spread of contamination and the inhalation of radionuclides.

Glass Product Sampling System

The glass product is expected to trap most of the radon in the glass matrix, so the only radiological concern is external exposure from other radionuclides, including radon daughters, in the glass. Since most of the radon will have been removed during melting, several days will be required for the radon to ingrow to equilibrium concentrations; and as a result, the daughters, which produce most of the dose, will not be present unless the sampling is delayed, or the sample is held for a week or so. The worst case dose rate from a two pound sample of glass is about 2 mrem/hr at a foot.

Water Hold-up Tank and Pump

Water in the hold-up tank is the condensate from the moisture-laden effluent from the hot oil screws. Since radon is released during the heating and agitation in the screws, the condensate will contain dissolved radon. Assuming that 10 acfm of air accompanies the water vapor generated by the hot oil screws, the concentration of radon in the air exiting the condenser will be 11.4 E6 pCi/L and the equilibrium concentration of radon in the water will be about 6.5 E5 pCi/L. Radon daughters will accumulate to this concentration, but this will not lead to the generation of high dose rates. The dose rate one foot from the side of the pump will be <1 mrem/hr. If this water is spilled, radon will be released to the atmosphere at a concentration that could be a concern for personnel exposure. Radon daughters will decay away in four hours after the radon is dispersed, so clean-up is best delayed, provided that the spillage is stopped and the quantity spilled is not large.

Quench Tank and Conveyor System

Material in the quench tank and conveyor system will consist of water, and wet glass particles. The glass product is expected to trap most of the radon in the glass matrix, so the only significant radiological concern is external exposure from other radionuclides, including radon daughters, in the glass. Since most of the radon will have been removed during melting, several days will be required for the radon to ingrow to equilibrium concentrations, and as a result, the daughters, which produce most of the dose, will not be present unless the glass is not transferred to a glass output bin within a day or two. The dose rate from the glass will increase as the radon ingrows and the radon daughters accompany it. After complete ingrowth (three weeks), the dose rate one foot from the side of the tank would be 130 mrem/hr. For shorter removal delays the dose rate will be lower and can be estimated as follows:

Delay (days)	Fraction of final dose rate
1	0.17
2	0.30
3	0.42
5	0.60

Glass Output Bin

Since it is expected that the radon will not escape from the glass, the radiological considerations associated with the storage of the glass output bins are limited to the external exposure. Should a bin be loaded to the top with 2.5 g/cm^3 glass with 33% void space, and stored until equilibrium is established between radium, radon, and the radon daughters, the dose rate one foot from the outside of the bin would be about 50 mrem/hr.

Table 1 presents the non-rad and rad concerns for each specific task that will be performed during the project. These concerns will be addressed throughout the project duration and managed by incorporating H&S requirements into the design, project specific procedures, training programs, utilizing appropriate levels of PPE, proper posting, proper access control, and proper monitoring.

Drag-Flite Quench Water Heat Exchanger

This heat exchanger cools water from the quench tank that only has traces of radionuclides. The dose rate adjacent to the tank will be less than 1 mrem/hr. The only radiological precaution is to see that water to be disposed of is sent through the Water Treatment System Package.

Evaporative Cooler

The evaporative cooler receives the off-gas from the CRV reactor and contacts it with water from the dryer condensate hold-up tank. All of the radon emitted in the process upstream of the CRV reactor is fed back into the reactor in the FDF air and most of it will come out in the off-gas. The expected concentration, if all of the radon were to be released, would be about 700,000 pCi/L. In the evaporative cooler, the water introduced flashes to steam and accompanies the off-gas stream to the baghouse. Particulates, radon, and radon daughters included in the off-gas will be carried out with the air-stream. Very little deposition occurs on the internal surfaces of the evaporator. Since the evaporator is lined with a layer of refractory which acts as a shield, the external dose rate will be no more than 1 mrem/hr. Internal contamination will be an issue during maintenance, but not of the magnitude seen in the process equipment upstream of the CRV reactor.

Baghouse

The off-gas/steam mixture passes through the baghouse where particulates are removed. The particulates collected are periodically "bumped" from the bag and recycled to the cyclone melter. The estimated average inventory in the baghouse is 100 pounds of solids. With this inventory, the dose rate outside of the baghouse (at one foot) would be 10 to 15 mrem/hr adjacent to the bag-filter area and up to 40 mrem/hr where the particles are collected in the bottom. The collection of powdery solids inside generates an inhalation hazard when the bags have to be changed, and personnel and the adjacent area will have to be carefully protected.

Pre-quench Tank

Recycle water is mixed with the off-gas/steam mixture exiting the baghouse, and some of the radon and most of any remaining particulates are transferred to the water. The equilibrium concentration of radon in the water for air at 700,000 pCi/L is about 400,000 pCi/L. Therefore, the water in the quench tank will come to approximate this concentration. Initially, this water will be essentially free of radon daughters, and the dose rate will be very low. However, the water will eventually be mixed with other water in the

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recycle water system and an equilibrium concentration of radon daughters will be established as well. However, even with radon daughters present at 400,000 pCi/L the dose rate will be <1 mrem/hr, and the potential for personnel exposure from small leaks will be manageable..

SOx Scrubber

Water in the shell side of the SOx Scrubber Sump Water Heat Exchanger will contain equilibrium concentrations of radon and radon daughters similar to that in the NOx scrubber, resulting in low local dose rates and manageable internal exposure problems should minor leakage occur.

NOx Scrubber Sump Recycle Pump and Back-up

Water in the NOx scrubber sump WTS pump and back-up will contain equilibrium concentrations of radon and radon daughters similar to that in the NOx scrubber, resulting in low local dose rates and manageable internal exposure problems should minor leakage occur.

SOx Scrubber Sump WTS Pump and Back-up

Water in the SOx scrubber sump WTS pump and back-up will contain equilibrium concentrations of radon and radon daughters similar to that in the NOx scrubber, resulting in low local dose rates and manageable internal exposure problems should minor leakage occur.

Drag-flite Ash Conveyor Recycle Pump

The drag-flite ash conveyor recycle pump circulates the quench water for cooling. The water has been in contact with the molten glass, and may contain traces of radionuclides including radon, and any fines generated during the quenching process. The fines will accumulate over time and have to be emptied out and returned to the melter. The expected dose rate at the pump is less than 1 mrem/hr, although higher doses (nominally 10 mrem/hr) might be seen where the fines collect. Since the water will contain some radionuclides, it should be disposed of, if or when necessary, through the Water Treatment System Package.

Dryer Screw Vapor Condenser

Water in the shell side of the dryer screw vapor heat exchanger will contain equilibrium concentrations of radon and radon daughters similar to that in the NOx scrubber, resulting in low local dose rates and manageable internal exposure problems should minor leakage occur.

SOx Scrubber Sump Water Heat Exchanger

Water in the shell side of the SOx scrubber sump water heat exchanger will contain equilibrium concentrations of radon and radon daughters similar to that in the NOx scrubber, resulting in low local dose rates and manageable internal exposure problems should minor leakage occur.

NOx Scrubber

All of the water in the off-gas treatment system contains dissolved radon and radon daughters. Radon is being constantly added as condensate enters the hold-up tank, and when the CRV reactor off-gas comes in contact with water that has less than an equilibrium concentration of radon. Radon will be removed from the water by radioactive decay and by escape into the gas whenever the air has lower than equilibrium concentrations present. As a result, the radon and radon daughters will reach an equilibrium in the water, likely at about 1E5 to 1E6 pCi/L. This will generate some low dose rates (<1 mrem/hr) in the vicinity of the equipment and piping, and represent a manageable internal exposure problem in the case of small leaks. Large leaks, e.g., 100s of gallons will require more stringent measures for personnel protection.

NOx Scrubber Chiller

Water in the shell side of the SOx scrubber sump water heat exchanger will contain equilibrium concentrations of radon and radon daughters similar to that in the NOx scrubber, resulting in low local dose rates and manageable internal exposure problems should minor leakage occur.

Radon Degasification Tank

The radon degasification tank reduces the concentration of radon in the water to meet this part of the waste acceptance criteria established for receipt of water by the AWWT system. Air is bubbled through the recycle water until the radon concentration is sufficiently reduced. The radon carried off by the air is returned to the FD fan for recycle through the CRV reactor. The dose rate from the tank is 1 to 2 mrem/hr, and the water in the tank contains trace radionuclides. Management of spilled material from a radiation protection standpoint is straightforward.

Water Treatment System Package

This package removes most of the trace radionuclides in the water destined for transfer to Fernald's Advanced Waste Water Treatment (AWWT) system. The concentration of radon will already have been reduced by the time the water gets to this system. Concentrations of other radionuclides are low and will be further reduced. The potential for either internal or external exposure is small. Normal RadCon precautions typical of a laboratory environment will be adequate.

Water Sampling System

The water in the sampling system will already be cleaned of most radon and other radionuclides and is anticipated to meet the Waste Acceptance Criteria for the AWWT system. The potential for either internal or external exposure is small. Normal RadCon precautions typical of a laboratory environment will be adequate.

HEPA Filtered Vacuum

Solids collected in a HEPA filtered vacuum will present a dose rate problem depending on the amount of material collected. A pound of dry waste material collected in one will give a dose rate of 2 mrem/hr at one foot. Since the material is a powdery solid, personnel protection measures will have to be taken to prevent the spread of contamination and the potential for exposure via inhalation when the bag is changed out or the cleaner otherwise opened.

FOSTER WHEELER ENVIRONMENTAL CORPORATION

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FDF Vortec Commercial Scale CMS™

Table 1. Health and Safety Concerns

CONSTRUCTION	NON-RAD CONCERNS	RAD CONCERNS
General Construction Activities	• General OSHA requirements • Proper training • PPE • Appropriate monitoring	N/A
Excavation	• Proper shoring • Confined space considerations	N/A
Pour slab	• General OSHA requirements	N/A
Pour walls, ceiling (or use prefabricated slabs)	• Hoisting/rigging considerations	N/A
Install studs, trusses and metal frame/roof	• Hoisting/rigging considerations • Fall protection	N/A
Install Equipment – Erection	• Hoisting/rigging considerations • Hot work requirements	N/A
– Large Equipment Installation	• Hoisting/rigging considerations	N/A
Install infrastructure (wiring, HVAC)	• Lockout/tagout	N/A
Test equipment	• Lockout/tagout	N/A
OPERATION General operation activities	• General industrial safety practices • Appropriate PPE • Proper training • Appropriate monitoring • Proper maintenance • Remote operations	• Dosimetry, bioassay • Appropriate PPE • Proper training • Appropriate monitoring
Process Material – Material slurried to the holding tank	• Spill/material management • Wastewater management/collection	• Radiological hazards–high • Contamination hazards–medium
– Centrifuges	• Spill/material management • Wastewater management/collection	• Radiological hazards–medium • Contamination hazards-medium
– Dewater in hot oil screw	• Condensate/off-gas collection • Wastewater management/collection • Spill/material management	• Radiological hazards–high • Contamination hazards–high
– Transfer to hammer mill	• Dust/particulate suppression/management • Spill/material management	• Radiological hazards–medium • Contamination hazards–high
– Agitate to obtain desired particle size	• Dust/particulate suppression/management • Spill/material management	• Radiological hazards – medium • Contamination hazards – high
– Transfer to dry feed hoppers via pneumatic conveyor system	• Dust/particulate suppression/management • Spill/material management	• Radiological hazards–low • Contamination hazards–high
– Store 95% dry material	• Dust/particulate suppression/management	• Radiological hazards-high • Contamination hazards-high
– Transfer by metering screw to feed blender unit	• Dust/particulate suppression/management • Spill/material management	• Radiological hazards–low • Contamination hazards–high
– Feed blender unit	• Dust/particulate suppression/management • Spill/material management • Glass additive management	• Radiological hazards–high • Contamination hazards–high
– Pour into quench tank	• Off-gas management/pre-treatment • Spill/material management	• Radiological hazards–low • Contamination hazards–low
– Collect sample for analysis		• Radiological hazards–low • Contamination hazards–low

Table 1 Health and Safety Concerns (Cont.)

	NON-RADON CONCERNS	RAD CONCERNS
Cask – Install lifting fixture to lid	• Hoisting/rigging considerations	N/A
– Transfer by conveyor and lift lid	• Hoisting/rigging considerations	NA
– Transfer to filling station	• Rigging cask appropriately	N/A
Containerize material – Fill cask using drag screw	• Spill/material management	• Radiological hazards–medium • Contamination hazards–low
– Transfer cask to station and replace lid	• Hoisting/rigging considerations	• Radiological hazards–medium • Contamination hazards–low
– Transfer cask to clean area and remove lifting fixture	• Decon considerations	• Radiological hazards–medium • Contamination hazards–low
– Button up cask	• Pinch considerations	• Radiological hazards–medium • Contamination hazards–low
– Survey cask and decontaminate if necessary	• Decon considerations	• Radiological hazards – medium • Contamination hazards – low
– Ship cask to storage or disposal site	• DOT requirements • Hoisting/rigging considerations	• Radiological hazards–medium • Contamination hazards–low
WASTE STREAMS – Collect and return water to TTA	• Spill/material management • Wastewater management/collection	• Radiological hazards–low • Contamination hazards–low
– Process off-gas	• Off-gas management/pre-treatment	• Radiological hazards–low • Contamination hazards–low
MAINTENANCE Perform equipment maintenance	• Lockout/tagout • Hoisting/rigging considerations	• Radiological hazards–high • Contamination hazards–high

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DRAWINGS

FOR THE

REMEDIATION OF SILOS 1&2 RESIDUES USING VORTEC CYCLONE MELTING SYSTEM (CMS^{TM})

PROOF-OF-PRINCIPLE CONCEPTUAL DESIGN

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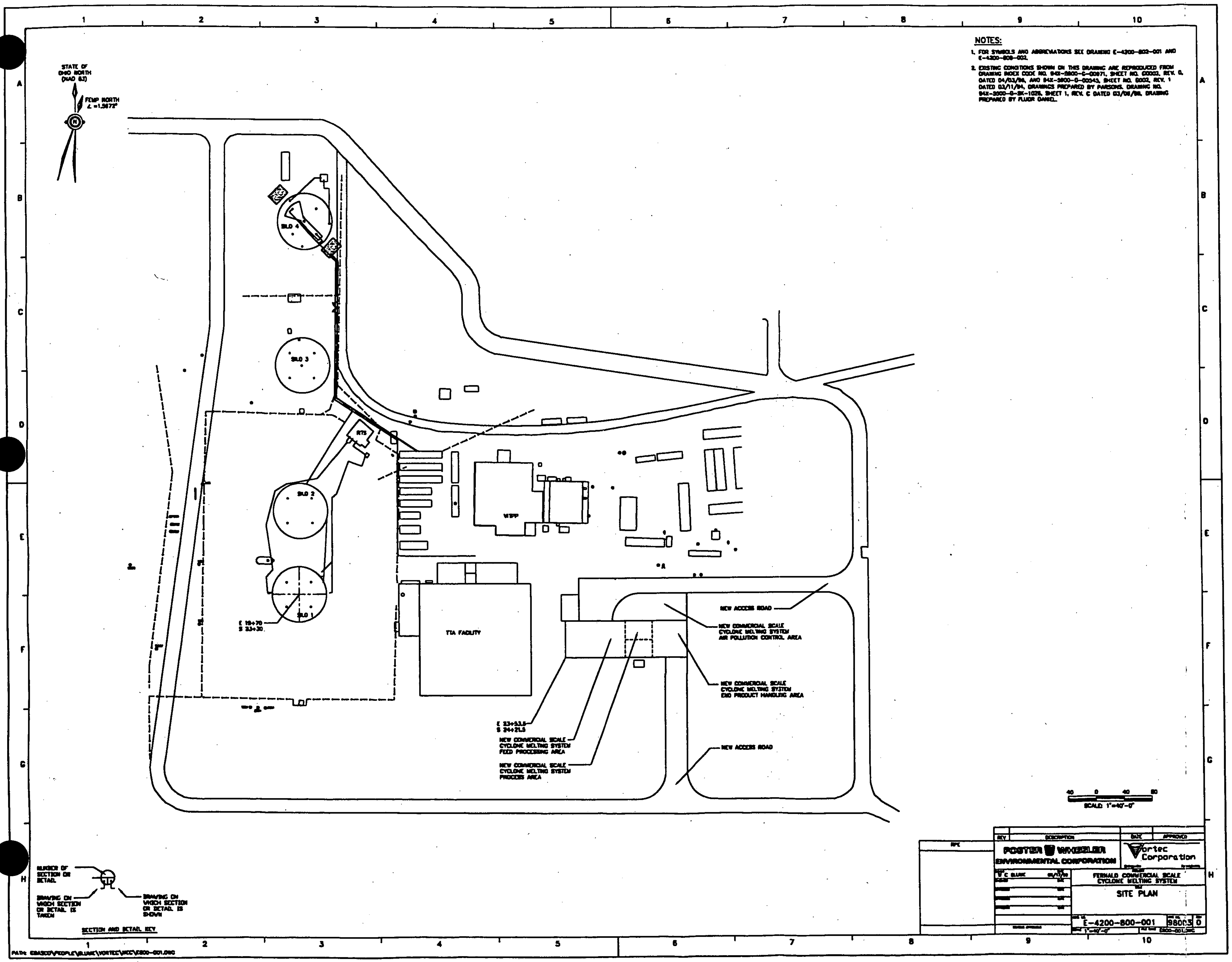

NOTES:
1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-802-001 AND E-4200-808-002.
2. EXISTING CONDITIONS SHOWN ON THIS DRAWING ARE REPRODUCED FROM DRAWING INDEX CODE NO. 94X-5800-C-00871, SHEET NO. C0002, REV. 0, DATED 04/03/96, AND 94X-5900-0-00543, SHEET NO. 0002, REV. 1 DATED 03/11/94, DRAWINGS PREPARED BY PARSONS. DRAWING NO. 94X-5000-0-SK-1026, SHEET 1, REV. C DATED 03/08/98, DRAWING PREPARED BY FLUOR DANIEL.
STATE OF OHIO NORTH (NAD 83)
FEMP NORTH
SILO 4
SILO 3
SILO 2
SILO 1
RTS
WTPP
TTA FACILITY
E 19+70
S 33+30
NEW ACCESS ROAD
NEW COMMERCIAL SCALE CYCLONE MELTING SYSTEM AIR POLLUTION CONTROL AREA
NEW COMMERCIAL SCALE CYCLONE MELTING SYSTEM END PRODUCT HANDLING AREA
E 33+53.5
S 34+21.5
NEW COMMERCIAL SCALE CYCLONE MELTING SYSTEM FEED PROCESSING AREA
NEW COMMERCIAL SCALE CYCLONE MELTING SYSTEM PROCESS AREA
NEW ACCESS ROAD
SCALE: 1"=40'-0"
NUMBER OF SECTION OR DETAIL
DRAWING ON WHICH SECTION OR DETAIL IS TAKEN
DRAWING ON WHICH SECTION OR DETAIL IS SHOWN
SECTION AND DETAIL KEY
REV
DESCRIPTION
DATE
APPROVED
FOSTER WHEELER ENVIRONMENTAL CORPORATION
Vortec Corporation
C BLANK
FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM
SITE PLAN
E-4200-800-001
98003
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1"=40'-0"

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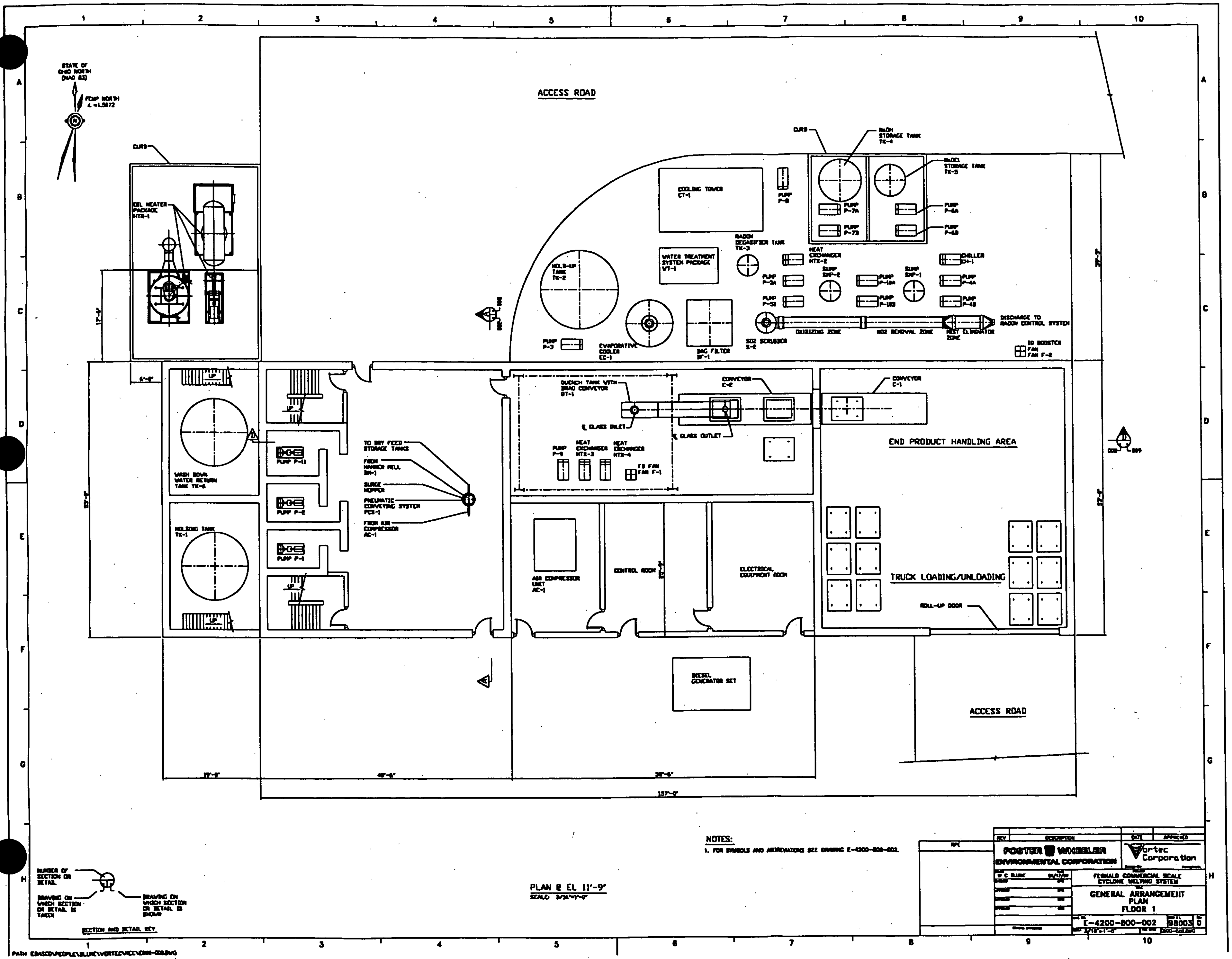

ACCESS ROAD
COOLING TOWER CT-1
WATER TREATMENT SYSTEM PACKAGE WT-1
HOLD-UP TANK TK-2
EVAPORATIVE COOLER EC-1
BAG FILTER BF-1
SO2 SCRUBBER S-2
OXIDIZING ZONE
NO2 REMOVAL ZONE
MIST ELIMINATOR ZONE
DISCHARGE TO RADON CONTROL SYSTEM
ID BOOSTER FAN FAN F-2
OIL HEATER PACKAGE HTR-1
WASH DOWN WATER RETURN TANK TK-6
HOLDING TANK TK-1
PUMP P-11
PUMP P-2
PUMP P-1
QUENCH TANK WITH DRAG CONVEYOR QT-1
CONVEYOR C-2
CONVEYOR C-1
END PRODUCT HANDLING AREA
AIR COMPRESSOR UNIT AC-1
CONTROL ROOM
ELECTRICAL EQUIPMENT ROOM
TRUCK LOADING/UNLOADING
ROLL-UP DOOR
DIESEL GENERATOR SET
ACCESS ROAD
157'-0"
NOTES:
1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.
PLAN @ EL 11'-9"
SECTION AND DETAIL KEY
FOSTER WHEELER ENVIRONMENTAL CORPORATION
Vortec Corporation
FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM
GENERAL ARRANGEMENT PLAN FLOOR 1
E-4200-800-002
98003
0

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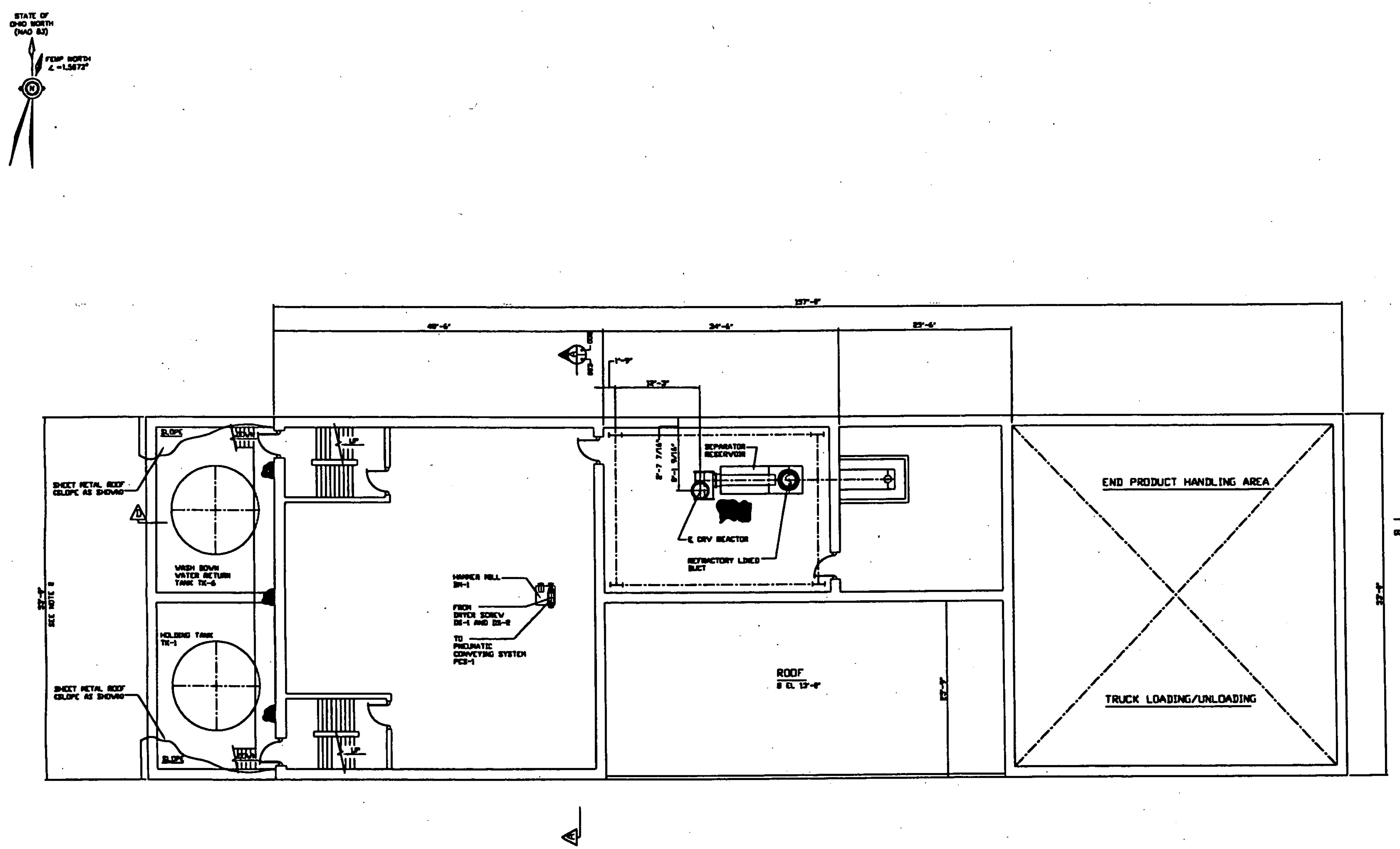
NOTES:
1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.



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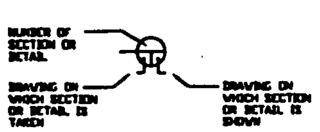

SECTION AND DETAIL KEY

REV	DESCRIPTION	DATE	APPROVED

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Vortec Corporation

FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM

GENERAL ARRANGEMENT PLAN FLOOR 2

E-4200-800-003 98003 0

3/16"=1'-0"

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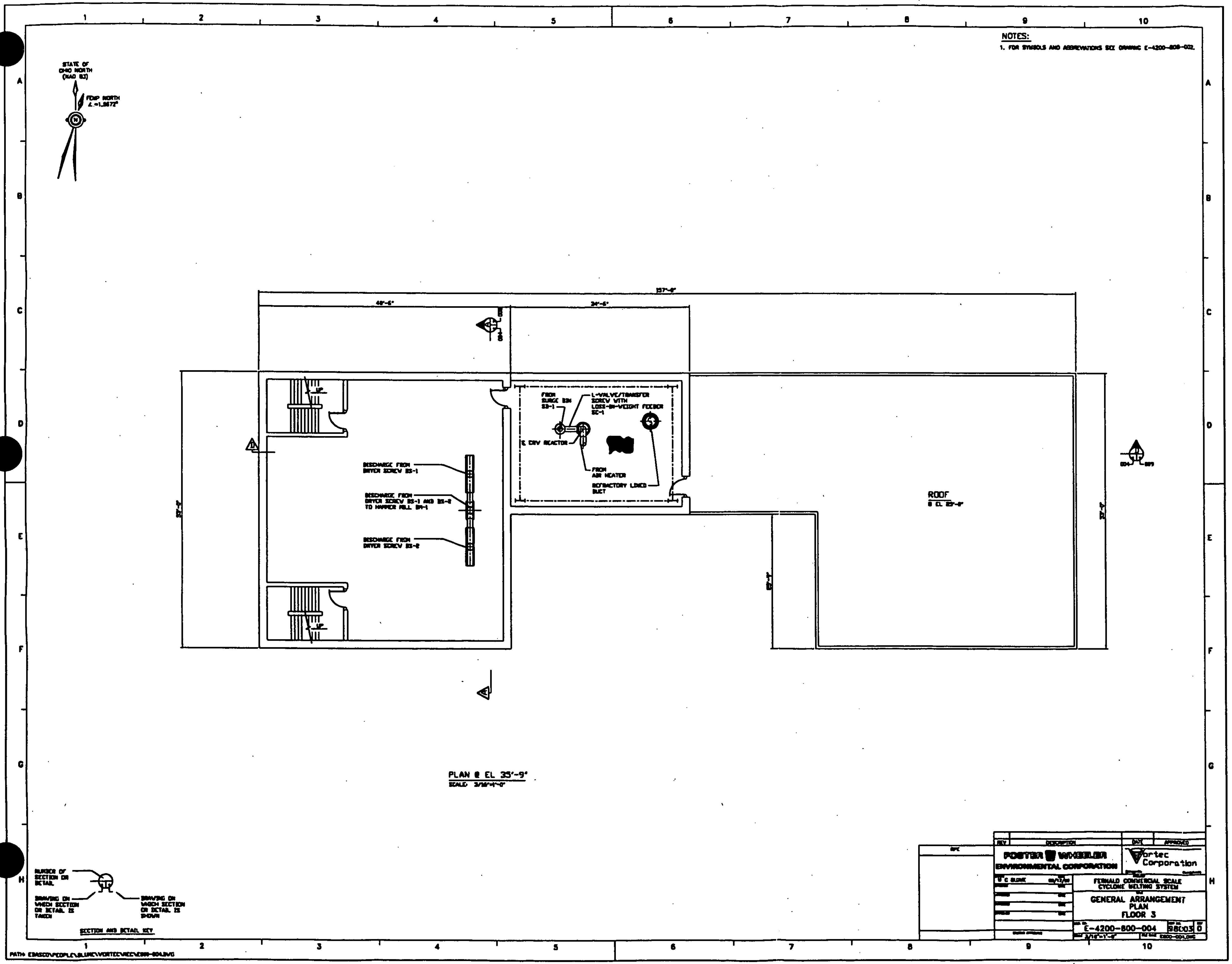
NOTES:
1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.
STATE OF OHIO NORTH (NAD 83)
FEMP NORTH
157'-9"
48'-6"
34'-6"
FROM SURGE BIN SB-1
L-VALVE/TRANSFER SCREW WITH LOSS-IN-WEIGHT FEEDER SC-1
℄ CMV REACTOR
FROM AIR HEATER
REFRACTORY LINED DUCT
DISCHARGE FROM DRYER SCREW DS-1
DISCHARGE FROM DRYER SCREW DS-1 AND DS-2 TO HAMMER MILL BM-1
DISCHARGE FROM DRYER SCREW DS-2
UP
ROOF
PLAN @ EL 35'-9"
SCALE: 3/16"=1'-0"
NUMBER OF SECTION OR DETAIL
DRAWING ON WHICH SECTION OR DETAIL IS TAKEN
DRAWING ON WHICH SECTION OR DETAIL IS SHOWN
SECTION AND DETAIL KEY
REV
DESCRIPTION
DATE
APPROVED
FOSTER WHEELER ENVIRONMENTAL CORPORATION
Vortec Corporation
FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM
GENERAL ARRANGEMENT PLAN FLOOR 3
E-4200-800-004
98C03
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3/16"=1'-0"

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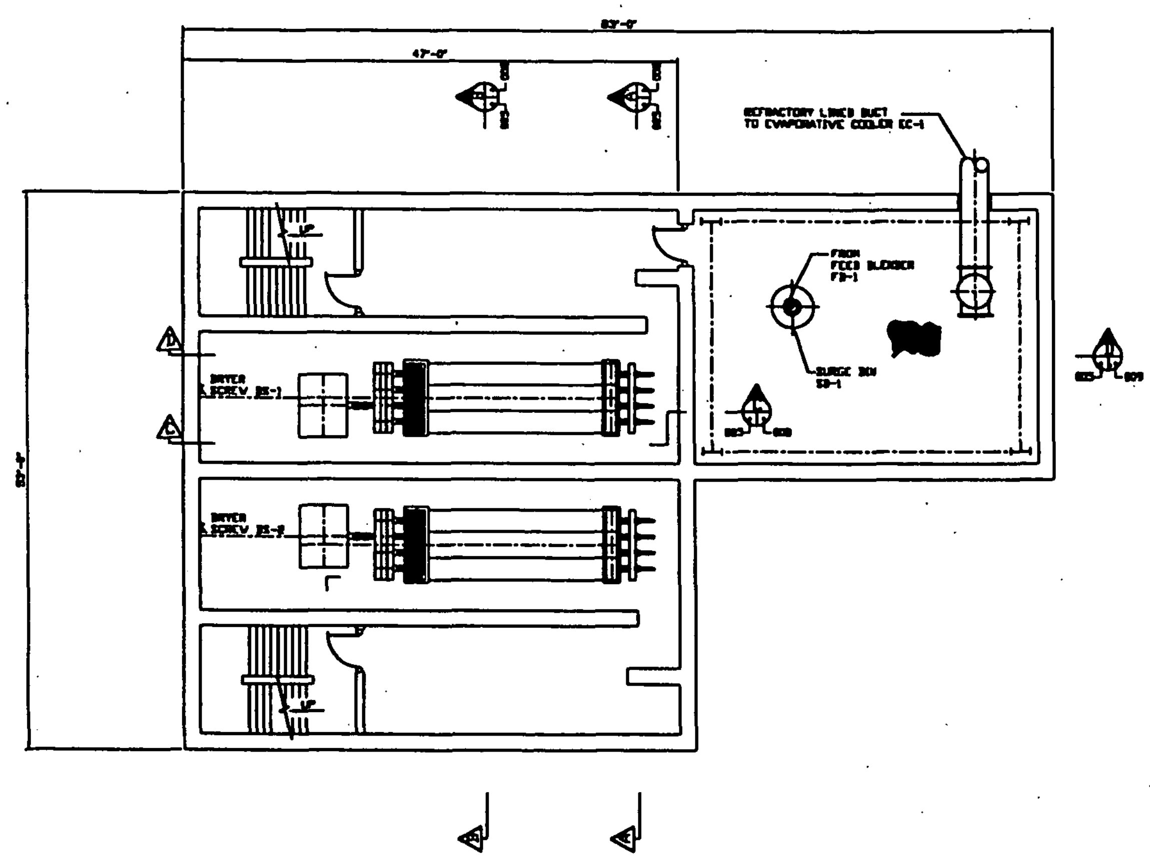
NOTES:

1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.



PLAN @ EL 47'-9"
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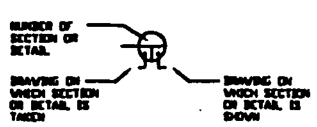

SECTION AND DETAIL KEY

REV	DESCRIPTION	DATE	APPROVED

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Vortec Corporation

C BLUME

FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM

GENERAL ARRANGEMENT PLAN FLOOR 4

E-4200-800-005 | 98003 | 0

3/16"=1'-0"

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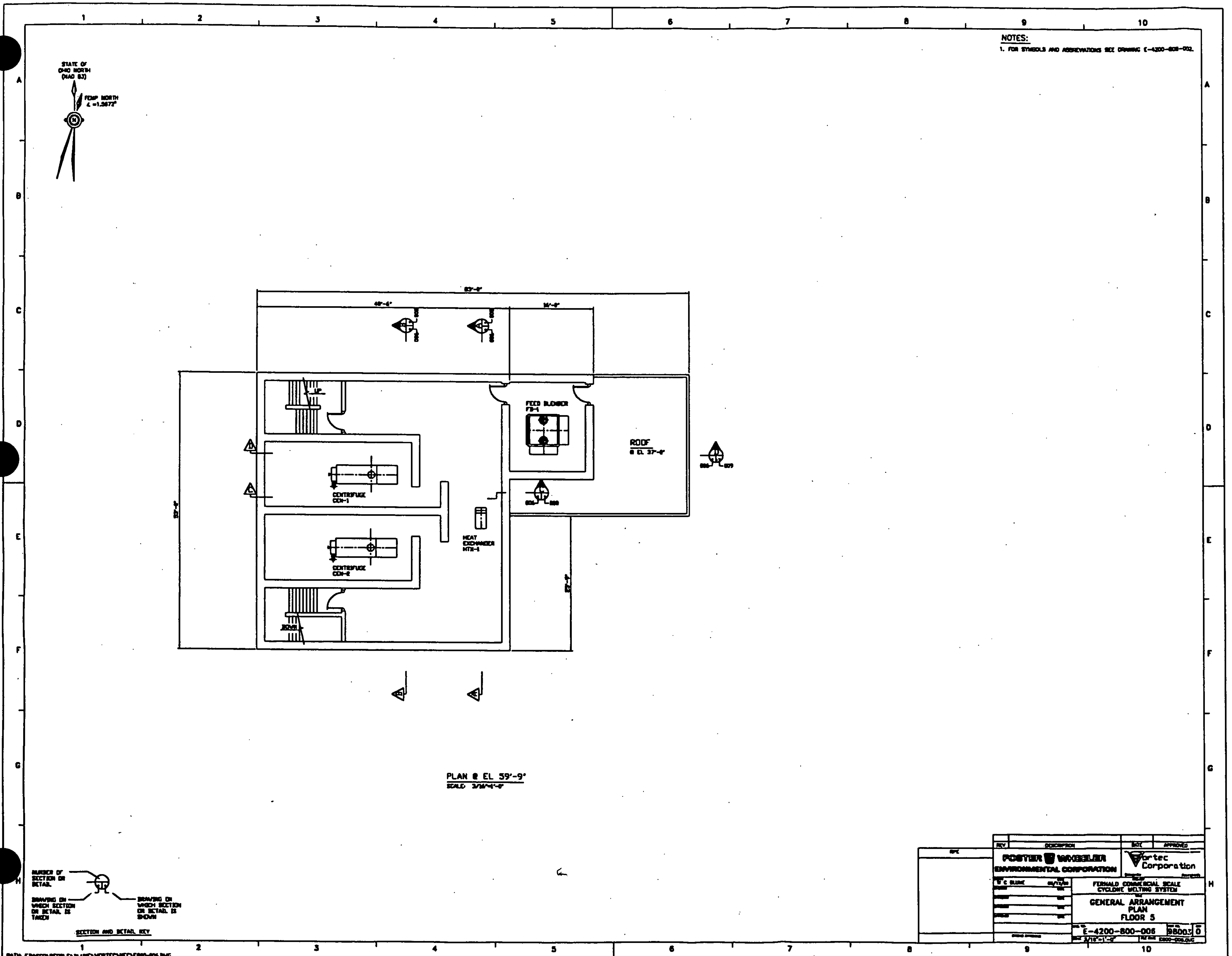

NOTES:
1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.
FEED BLOWER FB-1
ROOF
CENTRIFUGE CCN-1
CENTRIFUGE CCN-2
HEAT EXCHANGER HTX-1
UP
DOWN
PLAN @ EL 59'-9"
SECTION AND DETAIL KEY
FOSTER WHEELER ENVIRONMENTAL CORPORATION
Vortec Corporation
FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM
GENERAL ARRANGEMENT PLAN FLOOR 5
E-4200-800-006
0

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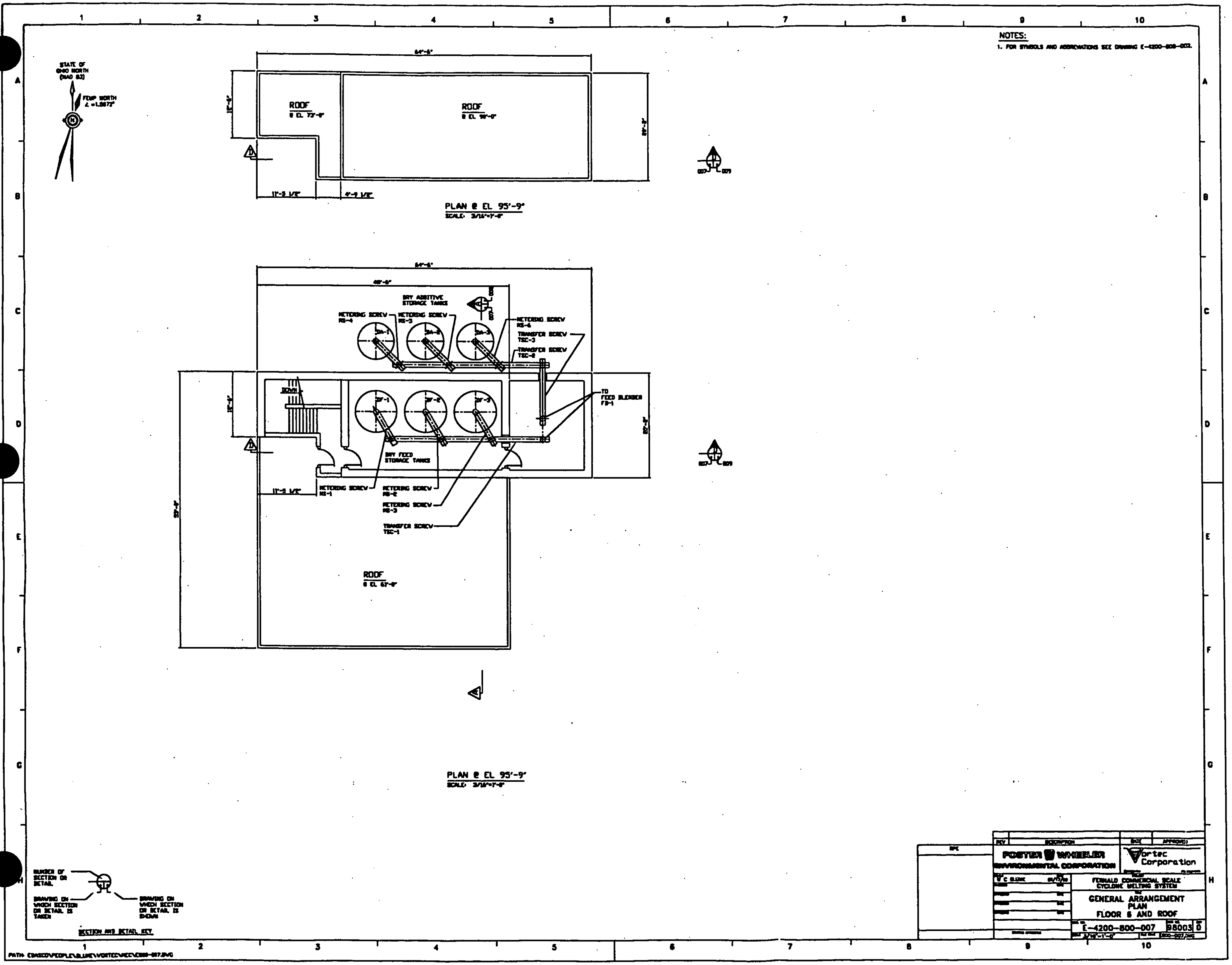
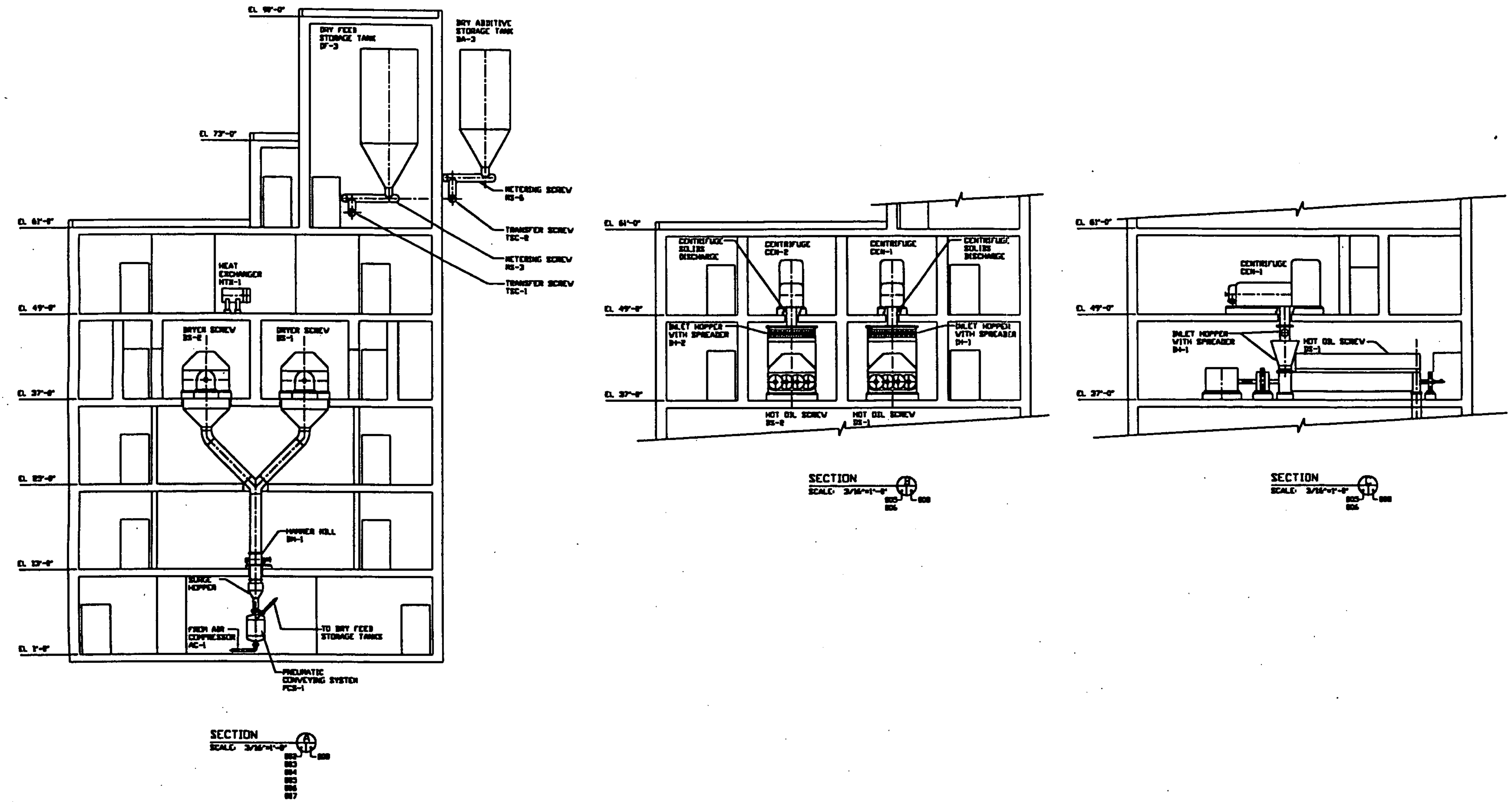
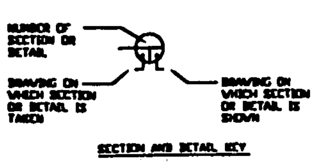

NOTES:
1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.
STATE OF OHIO NORTH (NAD 83)
ROOF
ROOF
PLAN @ EL 95'-9"
DRY ADDITIVE STORAGE TANKS
METERING SCREW MS-4
METERING SCREW MS-5
METERING SCREW MS-6
TRANSFER SCREW TSC-3
TRANSFER SCREW TSC-2
TO FEED BLENDER FB-1
DRY FEED STORAGE TANKS
METERING SCREW MS-1
METERING SCREW MS-2
METERING SCREW MS-3
TRANSFER SCREW TSC-1
ROOF
PLAN @ EL 95'-9"
SECTION AND DETAIL KEY
FOSTER WHEELER ENVIRONMENTAL CORPORATION
Vortec Corporation
FERNALD COMMERCIAL SCALE CYCLONIC MELTING SYSTEM
GENERAL ARRANGEMENT PLAN FLOOR 6 AND ROOF
E-4200-800-007
98003
0

000185

NOTES:
1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.





FOSTER WHEELER ENVIRONMENTAL CORPORATION	Vortec Corporation
FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM	
GENERAL ARRANGEMENT SECTIONS SHEET 1 OF 2	
E-4200-800-008	0

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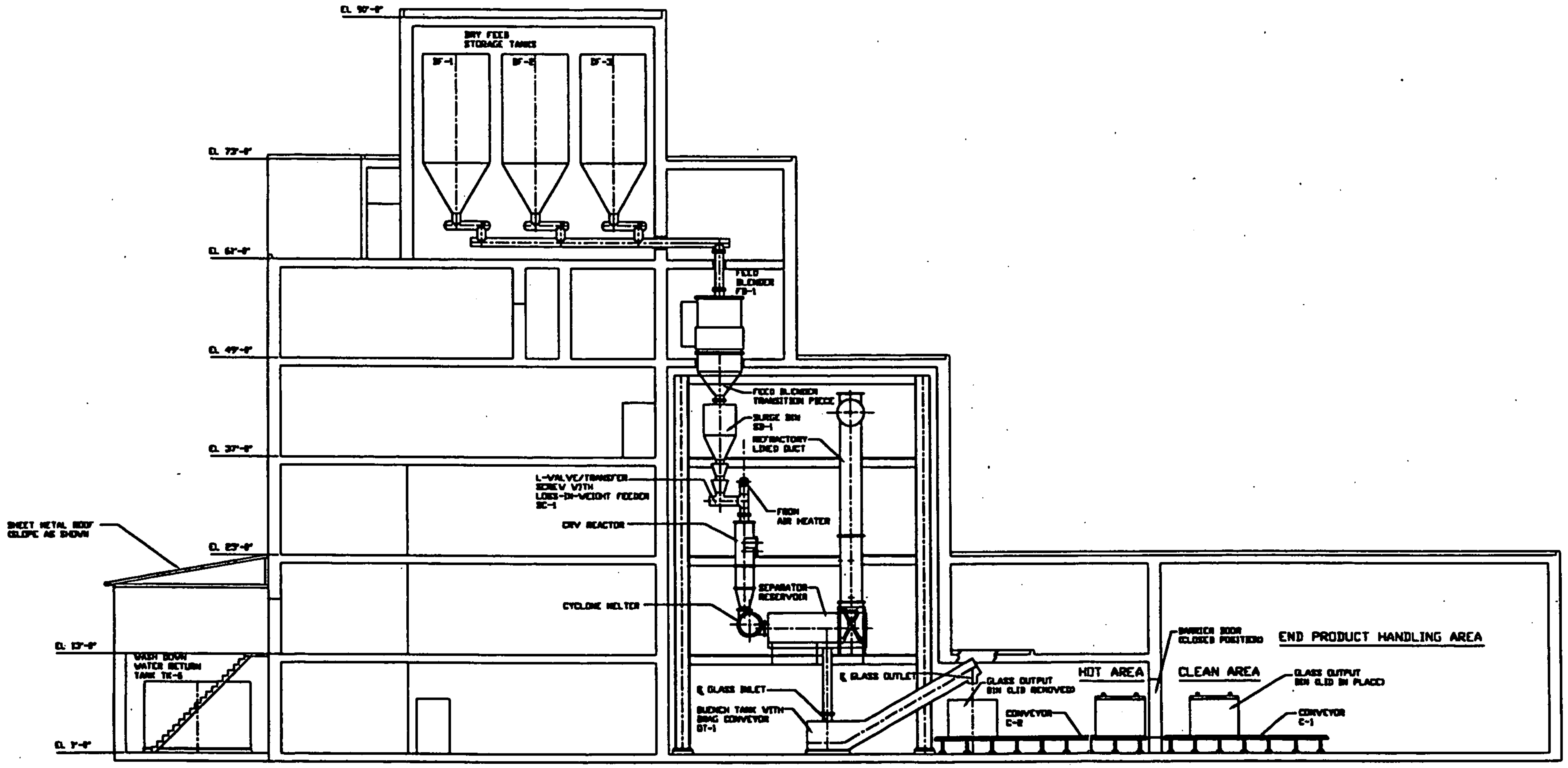
NOTES:

1. FOR SYMBOLS AND ABBREVIATIONS SEE DRAWING E-4200-800-002.



SECTION

SCALE: 3/16"=1'-0"

NUMBER OF SECTION OR DETAIL

DRAWING ON WHICH SECTION OR DETAIL IS TAKEN

DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

SECTION AND DETAIL KEY

REV	DESCRIPTION	DATE	APPROVED

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Vortec Corporation

V C BLUME

FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM

GENERAL ARRANGEMENT SECTIONS SHEET 2 OF 2

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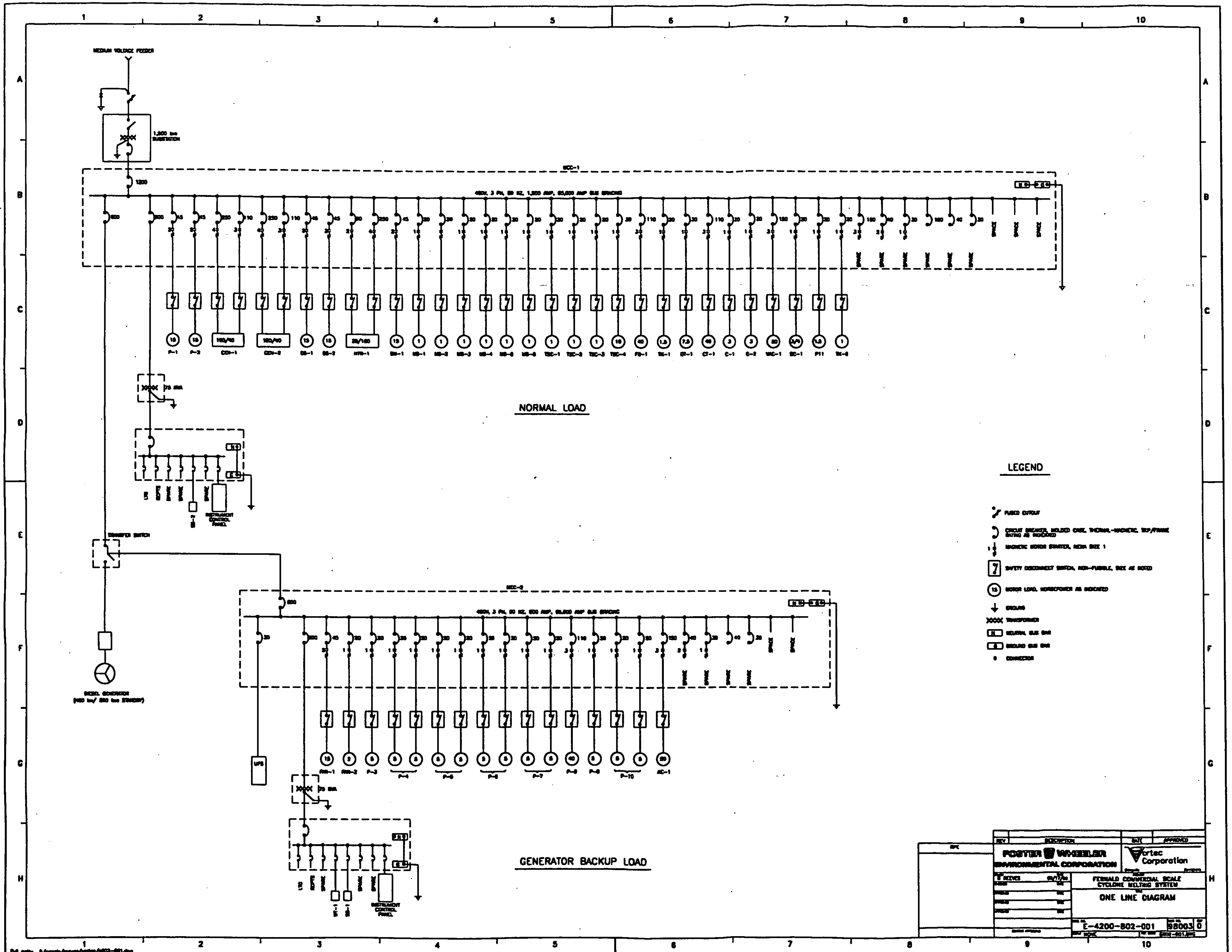

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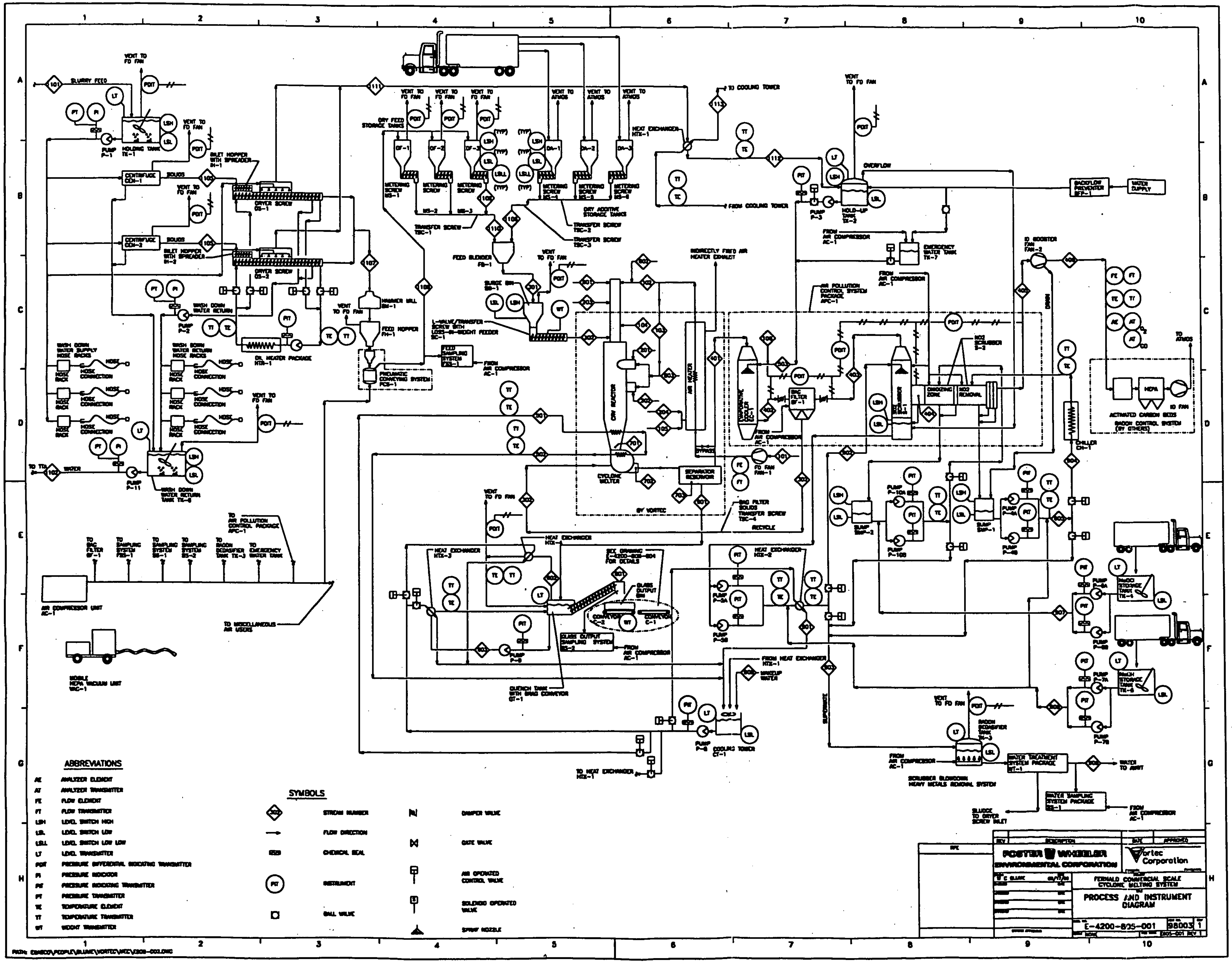

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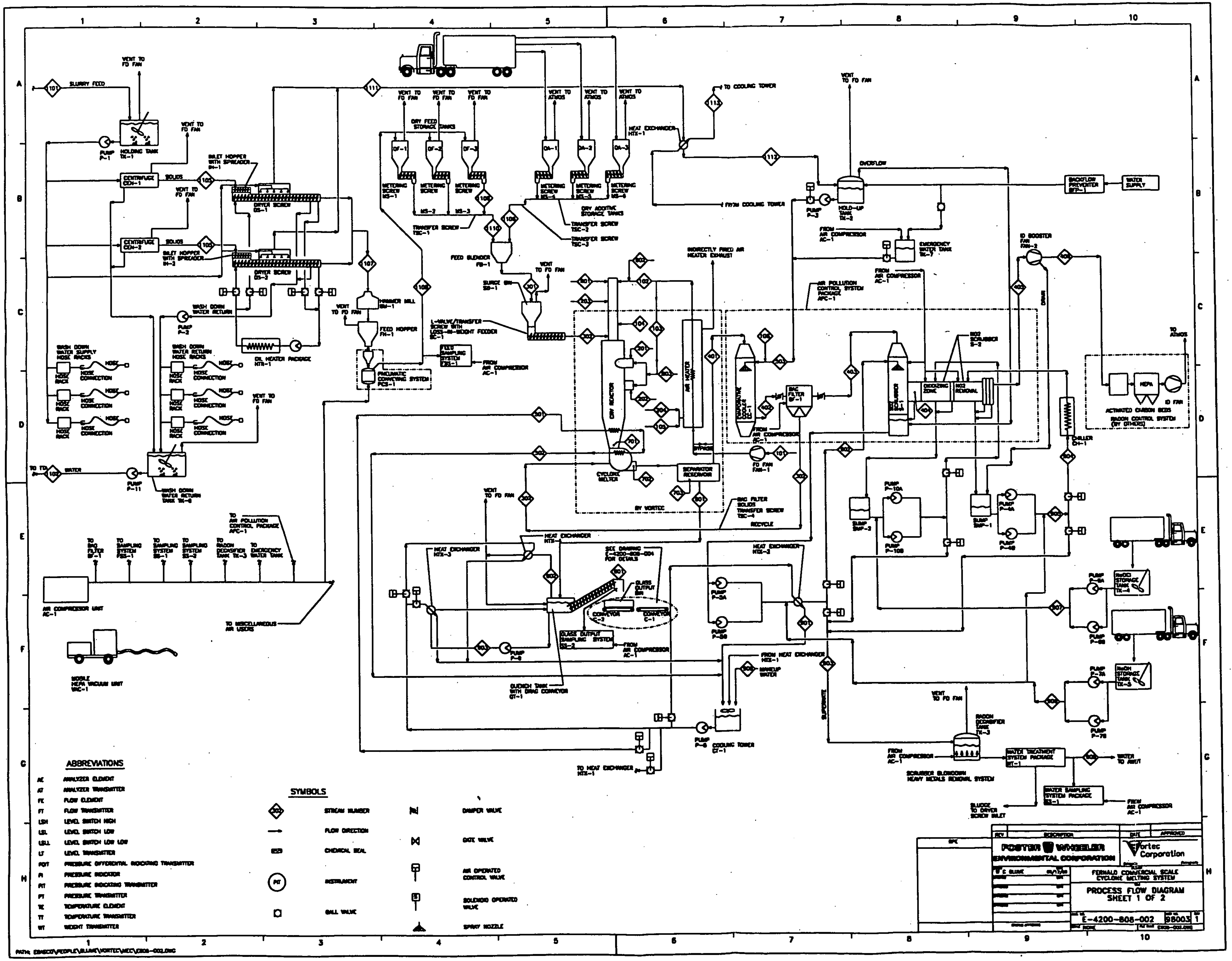

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GENERAL NOTES:
1. FOR SYMBOLS, AND ABBREVIATIONS SEE DRAWING E-4200-808-002.

Cyclone Melting System		101 Reactor Air to be Heated	102 Heated Air to Lid	103 Heated Air to Arms	104 Transport Air	105 Air to Air Heater Burner	201 Natural Gas to Arm A	202 Natural Gas to Arm B	203 Natural Gas to Lid	204 Natural Gas to Air Heater Burner	701 CRV Reactor	702 Cyclone Melter	703 Separator Reservoir	801 Oxygen to CMS Inlet	802 Oxygen to Lid	803 Oxygen to Arms
Mass Rate	lb/hr	2435	583	1704	148	780	60	60	52	42	4674	4674	4674	165	40	32
Density	lb/ft3	0.076	0.025	0.025	0.079	0.076	0.045	0.045	0.045	0.045	0.0139	0.0138	0.0137	0.084	0.084	0.084
Flow	acfm	531	391	1145	31	170	22	22	19	15	3782	3810	3829	33	8	6
Temperature	Deg. F	60	1200	1200	60	60	60	60	60	60	2350	2350	2350	60	60	60

Feed Prep System		1101 Slurry Feed	1102 TTA Recycle	1105 Dryer Screws	1106 Glass Additives	1107 Hammer Mill	1108 Pneumatic Conveyor	1109 Dry Feed Hopper	1110 Feed Transfer Screw	301 Feed to CRV Reactor	1111 Dryer Offgas	1112 Dryer Condensate	1113 Dryer Condensate Cooling Water
Mass Rate (lb/hr)	Total	59000	45100	16000	380	9780	9780	1155	1155	1535	7579	7579	253,300
	Water	53100	45100	8000	—	421	421	69	69	69	7579	7579	—
	Solids	5900	0	8000	380	9359	9359	1086	1086	1466	0	0	—
Density	lb/gal	8.72	8.33	—	—	—	—	—	—	—	—	8.33	—
	lb/ft3	—	—	76.2	90	90	90	90	90	90	0.037	62.4	—
Flow	gpm	113	90.2	—	—	—	—	—	—	—	—	15.2	506
	ft3/hr	907	725	210	4.2	104	104	12.8	12.8	17	—	121	—
	acfm	—	—	—	—	—	—	—	—	—	3385	—	—
Thermal Duty	MM Btu/hr	—	—	9.2	—	—	—	—	—	—	—	7.6	7.6
Temperature	Deg. F	60	60	60	60	250	250	60	60	60	212	180	115
Vent Air	acfm	—	12.1	10	—	10	10	10	10	10	10	10	—

Glass Product Handling System		601 Glass Product	501/502 CMS Cooling Water	602 Dragflight Steam Condensor	603 Dragflight Water Cooler
Mass Rate (lb/hr)	Total	1228	—	600	24000
	Water	—	33,665	600	—
	Solids lb/hr	1228	—	—	—
Density	lb/gal	—	—	—	—
	lb/ft3	150	—	0.037	—
Flow	gpm	—	67	—	.48
	ft3/hr	8.2	—	—	—
	acfm	—	—	268	—
Thermal Duty	MM Btu/hr	—	0.84	0.6	0.6
Temperature	Deg. F	110	110	212	110
Vent Air	acfm	—	—	10	—

Air Pollution Control System		401 CMS Offgas	402 Evaporative Cooler Offgas	403 Baghouse Offgas	404 SO2 Scrubber Offgas	405 NOx Scrubber Offgas	406 ID Booster Fan Offgas
Mass Rate lb/hr	Total	3446	4946	4653	2746	2691	2691
	Solids	295	295	1.5	1.5	1.5	1.5
	O_2	72.5	72.5	72.5	72.5	72.5	72.5
	N_2	1854.1	1854.1	1854.1	1854.1	1854.1	1854.1
	H_2O	485.2	1985.2	1985.2	105.0	53.0	53.0
	CO_2	710.1	710.1	710.1	710.1	710.1	710.1
	SO_2	26.7	26.7	26.7	0.11	0.11	0.11
	NOx	2.63	2.63	2.63	2.63	0.08	0.08
Temperature	Deg. F	2350	450	400	100	75	80
pressure	in. w.c.	0	-2	-6	-8	-10	5
Flow	acfm	3833	1839	1755	678	576	560
	scfm	708	1046	1046	617	546	546
Thermal Duty	MM Btu/hr	2.05	2.05	2.05	0.125	0.021	0.021

Air Pollution Control Liquid/Solid Waste Streams		503 Evaporative Cooler Water	302 Baghouse Solids Recycle	901 SO2 Scrub Cooling Water	902 SO2 Scrubber Recycle	903 SO2 & NOx Scrubber Purge	904 NOx Scrubber Recycle	905 NOx Scrubber Purge	906 20% Caustic Feed	907 Sodium Hypochlorite NaOCl	908 WWTP Purge	909 Cooling Tower Make-up
Mass Rate (lb/hr)	water	1500	—	47500	47500	1887	2600	48	139.5	—	1935	15000
	NaOH	—	—	—	—	—	—	—	34.86	—	—	—
	NaOCl	—	—	—	—	—	—	—	—	5	—	—
	Na_2SO_4	—	—	—	—	54.9	—	—	—	—	54.9	—
	Solids	—	295	—	—	—	—	—	—	—	—	—
Density	lb/gal	—	—	—	—	—	—	—	—	—	—	—
	lb/ft3	—	90	—	—	—	—	—	—	—	—	—
Thermal Duty	MM Btu/hr	—	—	1.9	-1.9	—	0.104	—	—	—	—	—
Temperature	Deg. F	—	250	125	100	100	75	100	60	—	75	60
Flow	gpm	3	—	95	95	3.8	20	0.10	0.28	—	3.87	30
	ft3/hr	—	2.1	—	—	—	—	—	—	—	—	—
Vent Air	(acfm)	10	—	—	—	—	—	—	—	—	10	—

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Vortec Corporation

FERNALD COMMERCIAL SCALE CYCLONE MELTING SYSTEM

PROCESS FLOW DIAGRAM
SHEET 2 OF 2

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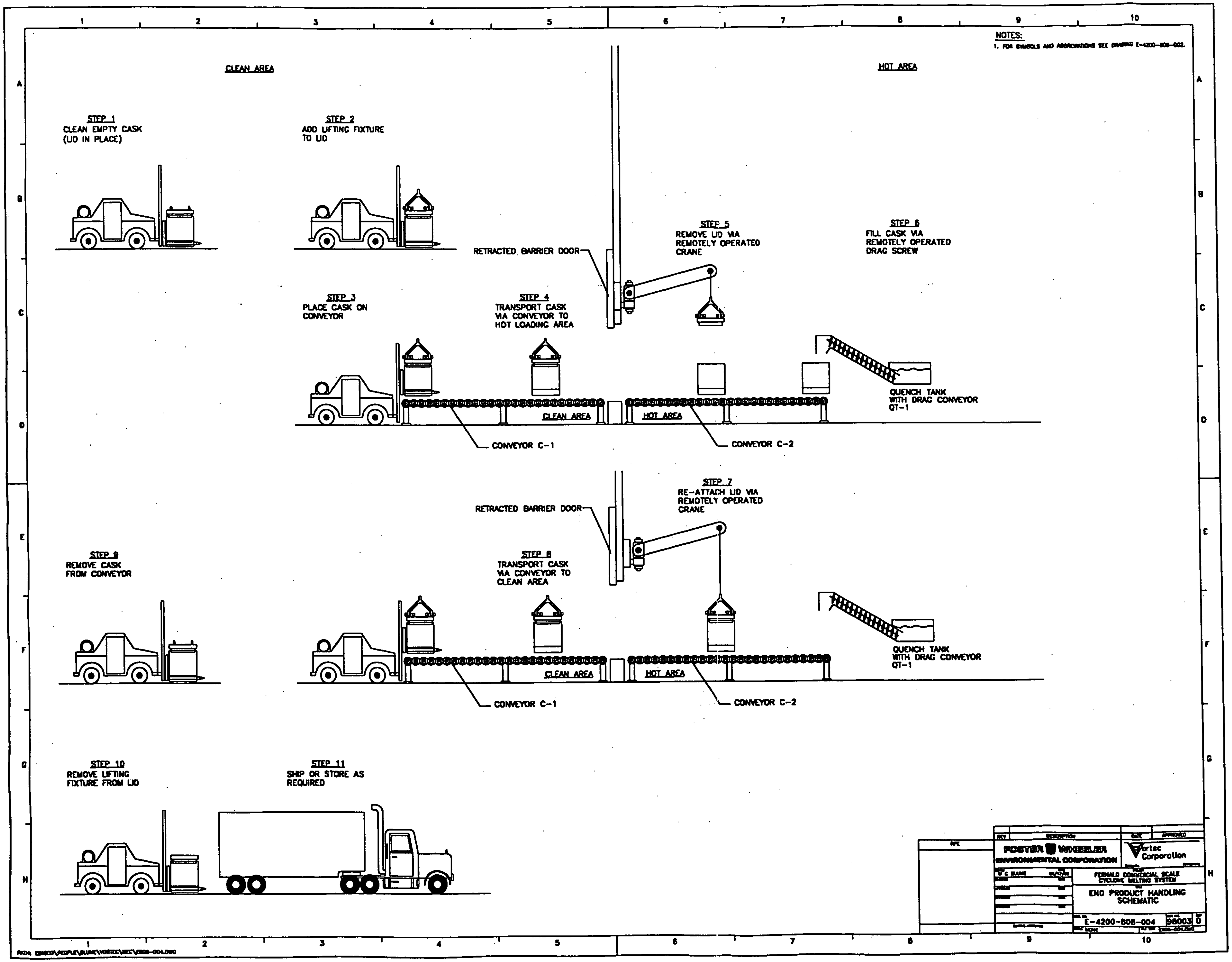

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SILO 1 AND SILO 2 PROOF OF PRINCIPLE PROJECT

APPENDIX D

Full-scale Plant Cost Estimate

Contract No. FDF 98WO002241
Report No. BFA-4200-809-002
Fernald Submittal No. 40720-2241-C5-004

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1.0 FULL-SCALE PLANT COST ESTIMATE

This estimate was derived to provide a preliminary cost estimate (± 30%) for the full-plant. Vortec Corporation and Foster Wheeler Environmental have cooperated in deriving the project cost.

Vortec Corporation is responsible for vitrification equipment and Foster Wheeler Environmental Company will provide the remaining equipment, balance-of-plant equipment, and construction of the full-scale facility. This cost estimate includes the following assumptions and conditions:

Assumptions and Conditions:

1. **Plant Cost**

a) No Construction or Equipment Installation Cost are included (FDF Contract instructions).
b) Utilities to the vitrification plant to be provided by others.
c) State and Federal Regulatory permits to be supplied by others.
d) Site of the plant to be provided by others.
e) Yard equipment to be provided by others.
f) Containers for the transporting the vitrified waste to be provided by others.
g) Plant Construction schedule is based on 40-hours/week at 10-hours/day.
h) Greater Cincinnati building & Construction Trades Counsel labor rates were used for start-up construction support labor.
i) 6.5% Ohio, Hamilton County, Sales Tax included with equipment, supplies, rentals, and materials.
j) Equipment and Operational Cost Data are valid for 90 days from final submittal of this report.

2. **Operational Cost**

a) On-site laboratory services to be supplied by others.
b) Environmental Regulatory Support to be supplied by others.
c) Transportation of the vitrified waste from the vitrification plant to be provided by others.
d) Operational Training to be provided by others.
e) Hazardous and Radiological Training to be provided by others.
f) Empty Cask Storage to be provided by others.
g) Fernald Operational Staffing Plan is in accordance with Fatlac Trades.
h) Operational Staffing includes labor type and hours only. Labor rates to be added by Fluor Daniel Fernald.

1.1 LONG LEAD ITEMS

The following long lead items will be required to support the construction schedule. Long lead items are identified in Table D-1, and require a lead-time greater than 12 weeks from when the purchase order is issued until delivery ship date.

Table D-1. Long Lead Items (> 12 weeks)

Item No.	Equip ID	Equip Name	Supplier	Lead Time (Wk) (ARO)
2	APC-1	APC System	TurboSonic Inc.	14
3	B-1	Pneumatic Conveying System	Smoot Co.	16
4	BH-1	Dalamatic Dust Collector	DeGroff Process Equip.	TBD
5	BM-1	Ball Mill	General Kinematics Corp.	13
7	BOP-x	Structural Steel, CMS™ Tower	TBD	16
9	C-1, C-2	Conveyor	Converor Systems & Engrg Inc.	16
10	CENT-1, CENT-2	Centrifuge	Andritz-Ruthner, Inc.	26
11	CH-1	NOX Scrubber Chiller	Edwards Engineering Corp.	26
12	CMS-1	Cyclone Melter System (CMS™)	Vortec Corporation	22
13	CRV-1	CRV Reactor System	Vortec Corporation	22
	CT-1	Cooling Twer	Fergusen Equipment Co.	16
15	DS-1, DS-2	Dryer Screw	Svedala Industries, Inc.	24
16	FB-1	Feed Blender	Hayes & Stoltz Industrial Mfg.	TBD
17	HTR-1	Thermal Fluid Heater	CTS Energy, Inc.	20
18	HTX-1	Heat Exchanger	Enviro-Systems, Inc.	TBD
21	QT-1	Quench Tank / Drag Conveyor	Webb-Materials Handling Equipment	20
22	SC-1	Loss-in Weight Feeder	Material Dynamics Inc.	20
23	SRGC-1	Water Cooled SR / GC System	Vortec Corporation	24
24	TSC-4	Baghouse Transfer Screw	Hayes & Stoltz Industrial Mfg.	TBD
	TK-1	TTA Slurry Hold-up Tank	Rodgers-Turner 7 Associates, Inc.	14
	TK-6	Washdown Water Return Tank	Rodgers-Turner 7 Associates, Inc.	14
25	VAH-1	Air Heater System	Vortec Corporation	20
26	WT-1	Water Treatment Package	L.C. Hammock Co., Inc.	TBD

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1.3 PROJECT COST SUMMARY

A project cost summary shown in Table D-2 includes a cost for equipment, construction, and start-up. The cost shown does not include G&A, Contingency, Insurance, Bonding , Contractor Fees, an Operational Readiness Review, or Preparation for a Operational Readiness Review. FDF contract instructions indicate that engineering, procurement, construction cost, and construction support by FWEC and Vortec Corporation are not to be included with the cost shown.

Table D-2. Project Equipment and Start-up Cost Summary

Item	Description	Cost	Note
1	Equipment	7,606,350	Includes Electrical & Piping
2	Start-up	755,562	Both Cold & Hot Start-up
	Total	**8,361,912**	

1.4. PLANT COST

Plant cost is grouped into Equipment Cost and Operating Cost. No construction or equipment installation cost are included.

1.4.1. Equipment Costs

Equipment cost includes the cost of the equipment and the cost of shipping it to the site. Additional Equipment Data Sheet information is shown in the Addendum to Appendix C. These data sheets include a narrative describing the function of the equipment. Equipment Cost Summary information is shown in Table D-3 and is sorted by system then by alphabetical listing of Equipment ID. Table D-3 is a summary listing of major equipment items providing a cost within ±30%. Vortec supplied equipment includes required instrumentation and a fire eye as part of the flame safety system. The Vortec supplied instrumentation and fire eye system are not listed as separate line items in Table D-3.

1.4.2 Piping, Electrical, Take-off's

The cost for piping and electrical take-off's are included with equipment costs summary shown in Table D-3. A detail breakdown for Piping is shown in Table I-4 and a detailed breakdown of the Electrical Cost is shown in Table D-5. The Cost for these items have been included in Table D-3 Equipment Cost.

1.4.3 Start-up Cost

System start-up is in two phases, Cold Start-up and Hot Start-up. Each series requires labor and consumables to conduct operations that verify the plant is ready for processing. Labor Cost for Cold Hot Start-up is shown in Table D-6. Cold start-up has a 2-month duration while hot start-up requires a 3-week period. Start-up cost includes craft service supplied by the construction contractor during the start-up time. Start-up costs also include subsistence and travel cost for both FWEC and Vortec Corporation. Consumable Cost for Cold and Hot Start-up are shown in Table D-7 and Table D-8. Labor rates quoted for cold and hot start-up are 1999 rates. Start-up costs do not include an Operational Readiness Review nor preparation for an Operational Readiness Review. Vortec Cold and Hot Start-up support is based on experience at Ormet. Vortec provides start-up support for the equipment supplied by Vortec and FWEC provides start-up support for all other equipment. Any required Operational Readiness Review Cost are assumed to be provided by FDF.

Table D-3. Equipment Cost Summary

Item	System	Sys No.	Equip Name	Equip ID	Qty	UM	Unit Cost	Freight	Equip Cost
1	Receiving	1	Holding Tank Transfer Pump	P-1	1	Ea	15,136	757	15,893
2	Receiving	1	TTA Transfer Pump	P-2	1	Ea	15,136	757	15,893
3	Receiving	1	TTA Slurry Hold-up Tank	TK-1	1	Ea	13,528	676	14,204
4	Receiving	1	Mixer for TTA Slurry Hold-up Tank	TK-1-1	1	Ea	8,018	404	8,422
5	Feed Prep	2	Centrifuge	CENT-1	1	Ea	328,659	16,253	344,912
6	Feed Prep	2	Centrifuge	CENT-2	1	Ea	328,659	16,253	344,912
7	Feed Prep	2	Dryer Screw	DS-1	1	Ea	369,351	18,397	387,748
8	Feed Prep	2	Dryer Screw	DS-2	1	Ea	369,351	18,397	387,748
9	Feed Prep	2	Inlet Hopper with Spreader	IH-1	1	Ea	5,350	270	5,620
10	Feed Prep	2	Inlet Hopper with Spreader	IH-2	1	Ea	5,350	270	5,620
11	Feed Prep	2	Thermal Fluid Heater	HTR-1	1	Ea	218,616	10,612	229,228
12	Feed Prep	2	Heat Exchanger	HTX-1	1	Ea	19,010	951	19,961
13	Feed Prep	2	Nitrogen System	NIT-1	1	Ea	1,065	0	1,065
14	Feed Prep	2	Condensate Hold-up Tank	TK-2	1	Ea	21,300	1,065	22,365
15	Feed Blending & Storage	3	Hammer Mill	BM-1	1	Ea	17,156	613	17,769
16	Feed Blending & Storage	3	Additive Storage Bin	DA-1	1	Ea	5,114	426	5,540
17	Feed Blending & Storage	3	Additive Storage Bin	DA-2	1	Ea	5,114	426	5,540
18	Feed Blending & Storage	3	Additive Storage Bin	DA-3	1	Ea	10,409	852	11,261
19	Feed Blending & Storage	3	Additive Storage Support	DA-x	1	Ea	43,371	1,278	44,649
20	Feed Blending & Storage	3	Dry Feed Storage Hopper	DF-1	1	Ea	5,675	426	6,101
21	Feed Blending & Storage	3	Dry Feed Storage Hopper	DF-2	1	Ea	5,675	426	6,101
22	Feed Blending & Storage	3	Dry Feed Storage Hopper	DF-3	1	Ea	5,675	426	6,101
23	Feed Blending & Storage	3	Feed Blender	FB-1	1	Ea	43,107	2,155	45,262
24	Feed Blending & Storage	3	Feed Sampling System	FSS-1	1	Ea	6,159	308	6,467
25	Feed Blending & Storage	3	Dry Feed Metering Screw	MS-1	1	Ea	8,469	423	8,892
26	Feed Blending & Storage	3	Dry Feed Metering Screw	MS-2	1	Ea	8,469	423	8,892

Table D-3. Equipment Cost Summary (Continued)

Item	System	Sys. No.	Equipment Name	Equip. ID	Qty	UM	Unit Cost	Freight	Equip Cost
27	Feed Blending & Storage	3	Dry Feed Metering Screw	MS-3	1	Ea	8,469	423	8,892
28	Feed Blending & Storage	3	Dry Feed Metering Screw	MS-4	1	Ea	9,056	453	9,509
29	Feed Blending & Storage	3	Dry Feed Metering Screw	MS-5	1	Ea	9,056	453	9,509
30	Feed Blending & Storage	3	Dry Feed Metering Screw	MS-6	1	Ea	11,623	581	12,204
31	Feed Blending & Storage	3	Pneumatic Conveying System	PCS-1	1	Ea	44,504	2,225	46,729
32	Feed Blending & Storage	3	Feed Hopper (Included with PSC-1)	FH-1	1	Ea	0	0	0
33	Feed Blending & Storage	3	Feed Blender	SB-1	1	Ea	5,325	266	5,591
34	Feed Blending & Storage	3	Loss-in Weight Feeder	SC-1	1	Ea	20,363	1,018	21,381
35	Feed Blending & Storage	3	Dry Feed Transporter	TSC-1	1	Ea	13,535	677	14,212
36	Feed Blending & Storage	3	Dry Feed Transporter	TSC-2	1	Ea	27,453	1,373	28,826
37	Feed Blending & Storage	3	Dry Feed Transporter	TSC-3	1	Ea	16,938	847	17,785
38	Vortec Vitrification System	4	Cyclone Melter System (CMS™)	CMS-1	1	Lot	1,095,751	0	1,095,751
39	Vortec Vitrification System	4	CRV Reactor System	CRV-1	1	Lot	1,052,951	0	1,052,951
40	Vortec Vitrification System	4	Water Cooled SR/GC System	SRGC-1	1	Lot	430,827	0	430,827
41	Vortec Vitrification System	4	Air Heater System	VAH-1	1	Lot	431,913	0	431,913
42	Vortec Vitrification System	4	Structural Steel, CMS™ Tower	VST-1	1	LS	394,449	0	394,449
43	Product Handling System	5	Powered Roller Conveyor	C-1	1	Ea	36,450	1,822	38,272
44	Product Handling System	5	Powered Roller Conveyor	C-2	1	Ea	36,450	1,822	38,272
45	Product Handling System	5	Drag Quench Water Heat Exchanger	HTX-3	1	Ea	6,390	320	6,710
46	Product Handling System	5	DF Vapor Heat Exchanger	HTX-4	1	Ea	6,390	320	6,710
47	Product Handling System	5	Jib Crain	JC-1	1	Ea	21,300	1,065	22,365
48	Product Handling System	5	Drag Conveyor Recycle Pump	P-9	1	Ea	15,136	757	15,893
49	Product Handling System	5	Quench Tank / Drag Conveyor	QT-1	1	Ea	133,125	6,656	139,781
50	Product Handling System	5	Glass Product Sampling System	SS-2	1	Ea	6,159	308	6,467
51	Air Pollution Control System	6	APC System	APC-1	1	Ea	453,434	0	453,434

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Table D-3. Equipment Cost Summary (Continued)

Item	System	Sys. No.	Equipment Name	Equip. ID	Qty	UM	Unit Cost	Freight	Equip Cost
52	Air Pollution Control System	6	Dalamatic Dust Collector (Baghouse)	BH-1	1	Ea	31,279	1,564	32,843
53	Air Pollution Control System	6	NOx Scrubber Chiller	CH-1	1	Ea	29,671	1,484	31,155
54	Air Pollution Control System	6	Evaporative Cooler (Incl w APC-1)	EC-1	1	Ea	0	0	0
55	Air Pollution Control System	6	Combustion Air Supply Fan	FAN-1	1	Ea	6,127	306	6,433
56	Air Pollution Control System	6	Induced Draft Booster Fan	FAN-2	1	Ea	2,523	126	2,649
57	Air Pollution Control System	6	Heat Exchanger	HTX-2	1	Ea	6,465	323	6,788
58	Air Pollution Control System	6	Oxidizing Zone Recycle Pump (Incl w APC-1)	P-10A	1	Ea	0	0	0
59	Air Pollution Control System	6	Oxidizing Zone Recycle Pump (Incl w APC-1)	P-10B	1	Ea	0	0	0
60	Air Pollution Control System	6	Water Hold-up Tank Pump	P-3	1	Ea	1,065	53	1,118
61	Air Pollution Control System	6	SOx Scrubber Sump Recycle Pump (Incl w APC-1)	P-4A	1	Ea	0	0	0
62	Air Pollution Control System	6	SOx Scrubber Sump Recycle Pump (Incl w APC-1)	P-4B	1	Ea	0	0	0
63	Air Pollution Control System	6	NOx Conditioner Sump Recycle Pump (Incl w APC-1)	P-5A	1	Ea	0	0	0
64	Air Pollution Control System	6	NOx Conditioner Sump Recycle Pump (Incl w APC-1)	P-5B	1	Ea	0	0	0
65	Air Pollution Control System	6	Urea Injection Pumps (Incl w APC-1)	P-6A	1	Ea	0	0	0
66	Air Pollution Control System	6	Urea Injection Pumps (Incl w APC-1)	P-6B	1	Ea	0	0	0
67	Air Pollution Control System	6	Caustic Storage Tank Pump (Incl w APC-1)	P-7A	1	Ea	0	0	0
68	Air Pollution Control System	6	Caustic Storage Tank Pump (Incl w APC-1)	P-7B	1	Ea	0	0	0
69	Air Pollution Control System	6	SO_2 Scrubber (Incl w APC-1)	S-1	1	Ea	0	0	0
70	Air Pollution Control System	6	NOx Scrubber (Incl w APC-1)	S-2	1	Ea	0	0	0

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Table D-3. Equipment Cost Summary (Continued)

Item	System	Sys. No.	Equipment Name	Equip. ID	Qty	UM	Unit Cost	Freight	Equip Cost
71	Air Pollution Control System	6	Sump Recirculation Tank (Incl w APC-1)	SMP-1	1	Ea	0	0	0
72	Air Pollution Control System	6	Sump Recirculation Tank (Incl w APC-1)	SMP-2	1	Ea	0	0	0
73	Air Pollution Control System	6	Radon Degasification Tank	TK-3	1	Ea	5,325	266	5,591
74	Air Pollution Control System	6	Urea Storage Tank (Incl w APC-1)	TK-4	1	Ea	0	0	0
75	Air Pollution Control System	6	Caustic Storage Tank (Incl w APC-1)	TK-5	1	Ea	0	0	0
76	Air Pollution Control System	6	Baghouse Transfer Screw	TSC-4	1	Ea	58,575	2,929	61,504
77	Water Treatment System	7	Water Sampling System	SS-1	1	Ea	8,189	409	8,599
78	Water Treatment System	7	Water Treatment Package	WT-1	1	Ea	47,925	2,396	50,321
79	Instrumentation & Control	8	I&C (PLC Programming)	I&C-1	1	LS	174,700	0	174,700
80	BOP, Other Process Equip	9	Air Compressor	AC-1	1	Ea	30,532	0	30,532
81	BOP, Other Process Equip	9	Radon Control System Duct	BOP-x1	1	LS	6,869	0	6,869
82	BOP, Other Process Equip	9	Viewing Portal	BOP-x2	1	Ea	10,000	0	10,000
83	BOP, Other Process Equip	9	Electrical (with Instruments)	BOP-x3	1	LS	528,514	42,396	570,860
84	BOP, Other Process Equip	9	Process Buildings	BOP-x4	1	LS	36,000	0	36,000
85	BOP, Other Process Equip	9	Control Room Furnishings	BOP-x5	1	LS	10,000	0	10,000
84	BOP, Other Process Equip	9	Process Piping	BOP-x6	1	LS	135,318	6766	142,084
85	BOP, Other Process Equip	9	Cooling Tower	CT-1	1	Ea	26,625	1,331	27,956
86	BOP, Other Process Equip	9	Oxygen Enrichment System (Leased, only pay for oxygen used)	O2-1	1	Ea	0	0	0
87	BOP, Other Process Equip	9	Washdown Return Water Pump	P-11	1	Ea	20,088	1,005	21,093
88	BOP, Other Process Equip	9	Cooling Tower Pump	P-8	1	Ea	6,092	305	6,397
89	BOP, Other Process Equip	9	Washdown Water Return Tank	TK-6	1	Ea	21,609	1,080	22,689
90	BOP, Other Process Equip	9	HEPA Filter Vacuum	VAC-1	1	Ea	52,877	2,644	55,521
			Totals						$ 7,606,350

Table D-4. Piping Takeoff Material Cost Summary

Piping Size	Description	Qty	UM	Unit	Cost	Sub Total
12" Dia Piping	**Material**					
	CS Sch 10 Pipe	370.00	LF	25.56	9,457	
	CS Sch 10, 90 Deg Bend	11.00	Ea	239.63	2,636	
	CS Sch 10, 45 Deg Bend	4.00	Ea	141.65	567	
	CS Sch 10, 150 # Flange	8.00	Ea	211.94	1,696	
	Acc Set, 150 # Flange	8.00	Ea	106.50	852	
	150# Butterfly Valve	4.00	Ea	617.70	2,471	$ 17,678
8" Dia Piping	**Material**					
	CS Sch 40 Pipe	40.00	LF	17.04	682	
	CS Sch 40, 90 Deg Bend	2.00	Ea	93.72	187	
	CS Sch 40, 45 Deg Bend	2.00	Ea	59.21	118	
	CS Sch 40, Tee	1.00	Ea	128.87	129	
	CS Sch 40, 150 # Flange	6.00	Ea	88.40	530	
	Acc Set, 150 # Flange	6.00	Ea	44.73	268	
	8" x 4" CS Sch 40 Reducer	1.00	Ea	47.07	47	
	150# Pneu Oper ContVlv	1.00	Ea	1,065.00	1,065	$ 3,027
4" Dia Piping	**Material**					
	CS Sch 40 Pipe	220.00	LF	6.39	1,406	
	CS Sch 40, 90 Deg Bend	4.00	Ea	20.77	83	
	CS Sch 40, 150 # Flange	4.00	Ea	31.95	128	
	Acc Set, 150 # Flange	4.00	Ea	15.98	64	
	4" x 2" CS Sch 40 Reducer	1.00	Ea	17.20	17	
	Gate Valve	1.00	Ea	830.70	831	
	Backflow Prevent Assbl	1.00	Ea	1,065.00	1,065	$ 3,594
2.5" Dia Piping	**Material**					
	CS Sch 40 Pipe	310.00	LF	3.73	1,156	
	CS Sch 40, 90 Deg Bend	17.00	Ea	8.09	138	
	CS Sch 40, 45 Deg Bend	6.00	Ea	24.28	146	
	CS Sch 40, Tee	11.00	Ea	23.43	258	
	CS Sch 40, 150 # Flange	18.00	Ea	11.72	211	
	Acc Set, 150 # Flange	18.00	Ea	532.50	9,585	
	150 # Pneu Oper ContV	2.00	Ea	319.50	639	
	Ball Valve	7.00	Ea	1,065.00	7,455	$ 19,587
	Material					
	CS Sch 40 Pipe	1,780.00	LF	2.66	4,735	
	CS Sch 40, 90 Deg Bend	139.00	Ea	7.24	1,006	
	CS Sch 40, 45 Deg Bend	16.00	Ea	6.60	106	
	CS Sch 40, Tee	74.00	Ea	19.73	1,460	
	CS Sch 40, 150 # Flange	56.00	Ea	21.30	1,193	
	Acc Set, 150 # Flange	56.00	Ea	10.65	596	
	CS Sch 40 Reducer	27.00	Ea	12.90	348	
	2" x 1" CS Sch 40 Threaded Cap	2.00	Ea	10.65	21	
	CS Sch 40 Thread-O-Let	2.00	Ea	10.65	21	
	150 # Pneu Oper ContV	6.00	Ea	479.25	2,876	

Table D-4. Piping Takeoff Material Cost Summary

Piping Size	Description	Qty	UM	Unit	Cost	Sub Total
2" Dia Piping	Gate Valve	38.00	Ea	489.90	18,616	
	Ball Valve	8.00	Ea	457.95	3,664	$ 34,642
1.5" Dia Piping	**Material**					
	CS Sch 40 Pipe	570.00	LF	1.60	912	
	CS Sch 40, 90 Deg Bend	54.00	Ea	5.33	288	
	CS Sch 40, 45 Deg Bend	6.00	Ea	5.33	32	
	CS Sch 40, Tee	26.00	Ea	15.98	415	
	CS Sch 40, 150 # Flange	22.00	Ea	17.04	375	
	Acc Set, 150 # Flange	22.00	Ea	8.52	187	
	CS Sch 40 Reducer	6.00	Ea	10.65	64	
	150 # Pneu Oper ContV	2.00	Ea	426.00	852	
	Ball Valve	4.00	Ea	213.00	852	
	150# Flanged B/F Valve	1.00	Ea	106.50	107	$ 4,084
1" Dia Piping	**Material**					
	CS Sch 40 Pipe	820.00	LF	1.07	877	
	CS Sch 40, 90 Deg Bend	54.00	Ea	4.26	230	
	CS Sch 40, 45 Deg Bend	9.00	Ea	4.26	38	
	CS Sch 40, Tee	53.00	Ea	12.78	677	
	CS Sch 40, 150 # Flange	100.00	Ea	13.85	1,385	
	Acc Set, 150 # Flange	100.00	Ea	6.92	692	
	CS Sch 40 Reducer	16.00	Ea	8.52	136	
	CS Sch 40 Threaded Cap	46.00	Ea	8.52	392	
	CS Sch 40 Threaded-O-Let	14.00	Ea	8.52	119	
	Pipe to Tube Adapter	14.00	Ea	8.52	119	
	Hose Bibb	14.00	Ea	79.88	1,118	
	Gate Valve	93.00	Ea	319.50	29,714	
	Check Valve	4.00	Ea	298.20	1,193	$ 36,692
1/2" Dia Piping	**Material**					
	CS Sch 40 Pipe	520.00	LF	0.80	416	
	CS Sch 40, 90 Deg Bend	90.00	Ea	3.20	288	
	CS Sch 40, 45 Deg Bend	10.00	Ea	3.20	32	
	CS Sch 40, Tee	8.00	Ea	9.56	76	
	CS Sch 40, 150 # Flange	55.00	Ea	10.65	586	
	Acc Set, 150 # Flange	55.00	Ea	5.33	293	
	CS Sch 40 Threaded Cap	3.00	Ea	6.39	19	
	150# Pneu Oper ContV	6.00	Ea	213.00	1,278	
	Gate Valve	32.00	Ea	266.25	8,520	
	Check Valve	1.00	Ea	244.95	245	
	Solonoid Valve	16.00	Ea	266.25	4,260	$ 16,014
					Sub-Total Cost	$ 135,318
					Shipping $	6,766
					Total Cost	**$ 142,084**

Table D-5. Electrical Material Cost Summary

Item	Description	Qty	UM	Unit Cost	Total Cost
1	Service Entrance	1	LS	20,035	20,035
2	Electric Equip	1	LS	164,552	164,552
3	Emergency System	1	LS	129,169	129,169
4	Building Grounds	1	LS	1,459	1,459
5	Instrumentation	1	LS	110,069	110,069
6	Lighting & Misc. Power	1	LS	134,393	134,393
7	Site Office & Storage	1	LS	11,183	11,183
				Total Cost	**$ 570,860**

Detail breakdown for Electrical Material Cost shown below:

Item	Description	Qty	UM	Unit Cost	Total Cost
1. SERVICE ENTRANCE - Base service entrance on 600 Amps @ Volts xx.xx					
1.1	500 KVA Xfmer - 13.2 KVA to 480 volt	1	EA	12,000.00	$ 12,000
1.2	Transformer Pad	2	CY	150.00	$ 300
1.3	Ground Rods W/ CAD Wells	3	EA	35.00	$ 105
1.4	4/o Copper Wire	50	FT	1.00	$ 50
1.5	2" PVC Conduit W/ Fittings	100	FT	2.70	$ 270
1.6	#6 15KV cable	360	FT	3.95	$ 1,422
1.7	15KV Termination	3	EA	50.00	$ 150
1.8	Concrete (In Duct Bank)	10	CY	100.00	$ 1,000
1.9	4" PVC Conduit & Fittings	280	FT	6.98	$ 1,954
1.10	350 MCM Copper Cable	720	FT	3.00	$ 2,160
1.11	#1 Copper Wire	200	FT	0.85	$ 170
1.12	350 MCM Terminations	16	EA	7.00	$ 112
1.13	#1 Terminations	4	EA	3.00	$ 12
				Sub-Total	$ 19,705
				Tax	$ 1,281
				Shipping	$ 1,049
	TOTAL SERVICE ENTRANCE				**$ 20,035**
2. ELECTRICAL EQUIPMENT					
2.1	Motor Control Center MCC1 - 400 Amp Main	1	EA	45,400.00	$ 45,400
2.2	Motor Control Center MCC2 - 150 Amp Main	1	EA	15,600.00	$ 15,600
2.3	30 Amp Disconnect	28	EA	125.00	$ 3,500
2.4	60 Amp Disconnect	29	EA	145.00	$ 4,205
2.5	100 Amp Disconnect	2	EA	265.00	$ 530
2.6	200 Amp Disconnect	1	EA	510.00	$ 510
2.7	UPS System	1	LS	14,600.00	$ 14,600
2.8	Disconnect Supports	20	EA	20.00	$ 400
2.9	Lighting Pads	2	EA	1,500.00	$ 3,000
2.10	Power Pads	3	EA	2,000.00	$ 6,000
2.11	Misc. Xformers	5	EA	3,000.00	$ 15,000
	5 HP Motors & Less				
2.12	3/4" RGS Conduit & Fittings	6,200	LF	3.00	$ 18,600
2.13	#12 Wire	30,000	LF	0.06	$ 1,800
2.14	Terminations	248	EA	0.50	$ 124

Table D-5. Electrical Material Cost Summary (Continued)

Item	Description	Qty	UM	Unit Cost	Total Cost
2.15	Motor Connections	31	EA	10.00	$ 310
	10 HP Motors				
2.16	3/4" RGS Conduit & Fittings	400	LF	3.00	$ 1,200
2.17	#10Wire	1,800	LF	0.06	$ 108
2.18	Terminations	16	EA	0.50	$ 8
2.19	Motor Connections	2	EA	10.00	$ 20
	15 HP Motors				$ -
2.20	1" RGS Conduit & Fittings	1,000	LF	4.00	$ 4,000
2.21	#8Wire	4,400	LF	0.20	$ 880
2.22	Terminations	40	EA	1.25	$ 50
2.23	Motor Connections	5	LF	15.00	$ 75
	20HP Motors				
2.24	1" RGS Conduit & Fittings	800	LF	4.00	$ 3,200
2.25	#8Wire	3,500	LF	0.20	$ 700
2.26	Terminations	32	EA	1.25	$ 40
2.27	Motor Connections	4	EA	20.00	$ 80
	30HP Motor				$ -
2.28	1 1/2" RGS Conduit & Fittings	200	LF	6.30	$ 1,260
2.29	#6Wire	880	LF	0.26	$ 229
2.30	Terminations	8	EA	1.50	$ 12
2.31	Motor Connection	1	EA	30.00	$ 30
	100 HP Motor				
2.32	2 1/2" FMC Conduit & Fittings	200	LF	13.40	$ 2,680
2.33	3/o Wire	880	LF	1.45	$ 1,276
2.34	Terminations	8	EA	10.00	$ 80
2.35	Motor Connection	1	EA	50.00	$ 50
2.36	40 Amp Power Center	1	LS	2,000.00	$ 2,000
				Sub-Total	$ 147,157
				Tax	$ 9,565
				Shipping	$ 7,836
	TOTAL ELECTRICAL EQUIPMENT				**$ 164,552**
3. Emergency System					
3.1	500 KWA Generator	1	EA	65,000.00	$ 65,000
3.2	600 Amp ATS Switch	1	EA	7,640.00	$ 7,640
3.3	Motor Control Center MCC-E	1	EA	15,200.00	$ 15,200
3.4	UPS System	1	LS	14,600.00	$ 14,600
	30HP Motor				$ -
3.5	1 1/2" RGS Conduit 7 Fittings	600	LF	6.30	$ 3,780
3.6	#6Wire	2,640	LF	0.26	$ 686
3.7	Terminations	24	EA	1.50	$ 36
3.8	Motor Connection	3	EA	30.00	$ 90
					$ -
3.9	Concrete	10	CY	100.00	$ 1,000
3.10	4" PVC & Fittings	280	FT	6.98	$ 1,954

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Table D-5. Electrical Material Cost Summary (Continued)

Item	Description	Qty	UM	Unit Cost	Total Cost
3.11	350 MCM Copper Cable	720	FT	3.00	$ 2,160
3.12	#1 Copper Wire	200	FT	0.85	$ 170
3.13	350 MCM Terminations	16	EA	7.00	$ 112
3.14	#1 Terminations	4	EA	3.00	$ 12
					$ -
3.15	4" RGS Conduit & Fittings	50	LF	26.00	$ 1,300
3.16	350 MCM Wire	350	FT	0.85	$ 298
3.17	#1 Terminations	16	EA	7.00	$ 112
3.18	2" RGS Conduit & Fittings	80	LF	8.00	$ 640
3.19	3/0 wire	480	LF	1.50	$ 720
				Sub-Total	$ 115,510
				Tax	$ 7,508
				Shipping	$ 6,151
				TOTAL EMERGENCY SYSTEM	**$ 129,169**
4. BUILDING GROUNDING					
4.1	4/0 Bare Wire	500	LF	1.86	$ 930
4.2	Ground Rods	15	EA	25.00	$ 375
				Sub-Total	$ 1,305
				Tax	$ 85
				Shipping	$ 69
				TOTAL BUILDING GROUNDING	**$ 1,459**
5. INSTRUMENTATION (Excludes Vortec Supplied Instrumentation)					
5.1	Pressure Xmitter (PT)	3	EA	1,200.00	$ 3,600
5.2	Pressure Indicator (PI)	2	EA	200.00	$ 400
5.3	Diff. Pressure Xmitter (PDIT)	8	EA	1,500.00	$ 12,000
5.4	Pressure Ind. Xmitter (PIT)	11	EA	1,200.00	$ 13,200
5.5	Level Xmitter	5	EA	1,200.00	$ 6,000
5.6	Level Switch	3	EA	100.00	$ 300
5.7	Level Probe	10	EA	500.00	$ 5,000
5.8	Flow Element	2	EA	150.00	$ 300
5.9	Flow Xmitter	2	EA	1,200.00	$ 2,400
5.10	Temperature Element	13	EA	150.00	$ 1,950
5.11	Temperature Xmitter	13	EA	1,000.00	$ 13,000
5.12	Weight (Load Cell)	3	EA	500.00	$ 1,500
5.13	Instrument Stands	42	EA	150.00	$ 6,300
5.14	Tubing	160	LF	20.00	$ 3,200
5.15	3/4' RGS Conduit & Fittings	9,000	LF	3.00	$ 27,000
5.16	1 Pn TWSHLD Wire	12,000	LF	0.14	$ 1,680
5.17	Terminations	42	LF	1.00	$ 400
				Sub-Total	$ 98,430
				Tax	$ 6,398
				Shipping	$ 5,241
				TOTAL INSTRUMENTATION	**$ 110,069**

Table D-5. Electrical Material Cost Summary (Continued)

Item	Description	Qty	UM	Unit Cost	Total Cost
6. LIGHTING & MISCELLANEOUS POWER					
	LIGHTING				
6.1	Fixtures - 250W MetalHalide	266	EA	264.00	$ 70,224
6.2	3/4" RGS Conduit & Fittings	5,000	LF	3.00	$ 15,000
6.3	#12 Wire	22,500	LF	0.06	$ 1,350
6.4	Terminations	1,595	EA	0.20	$ 319
6.5	Emergency Lights	19	EA	150.00	$ 2,850
6.6	Exit Lights	12	EA	45.00	$ 540
6.7	3/4" RGS Conduit & Fittings	1,840	LF	3.00	$ 5,520
6.8	#12 Wire	7,500	LF	0.06	$ 450
6.9	Terminations	186	EA	0.50	$ 93
6.10	Recepticles	197	EA	10.00	$ 1,970
6.11	3/4" RGD Conduit & Fittings	6,566	LF	3.00	$ 19,698
6.12	#12 Wire	26,264	LF	0.06	$ 1,576
6.13	Terminations	1,182	EA	0.50	$ 591
				Sub-Total	$ 120,181
				Tax	$ 7,812
				Shipping	$ 6,400
				TOTAL LIGHTING	**$ 134,393**
7. SITE OFFICES/STORAGE					
7.1	Small Tools	1	LS	10,000.00	$ 10,000
				Sub-Total	$ 10,000
				Tax	$ 650
				Shipping	$ 533
				TOTAL SITE OFFICES/STORAGE	**$ 11,183**

Table D-6. Cold and Hot Start-up Labor Cost

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Category	Description	Qty	UM	Rate	Cost	Sub Total
FWEC						
Site Field Personnel						
	Site Manager	472	Hr	80.83	38,152	
	Project Engineer	134	Hr	80.83	10,831	
	QA/QC	472	Hr	73.39	34,640	
	HSO	268	Hr	43.64	11,696	95,319
Other Site Personnel						
	Project Controls Engineer	236	Hr	65.53	15,465	
	Buyer	268	Hr	43.64	11,696	
	Field Accountant	268	Hr	36.91	9,892	37,053
Other Project Personnel						
	Project Manager	134	Hr	99.14	13,285	
	Procurement Manager	27	Hr	65.52	1,769	
	ESH Director	5	Hr	99.14	496	
	Regional ESH Manager	11	Hr	80.83	889	
	Environmental Compliance	54	Hr	65.53	3,539	19,978
Travel & Living Allowance			LS		62,100	62,100
	FWEC Totals	**2,349**				**$214,450**
Vortec						
Site Field Personnel						
	Engineer Level 5	160	Hr	106.76	17,082	
	Engineer Level 4	400	Hr	91.06	36,424	
	Engineer Level 2	400	Hr	56.71	22,684	
	Tech – A/Operator	80	Hr	47.55	3,884	80,074
Other Project Personnel						
	Company Management	60	Hr	206.00	12,360	
	Project Engineer	134	Hr	118.05	15,819	
	Engineer Level 6	134	Hr	117.31	15,720	
	Engineer Level 5	48	Hr	106.76	5,125	
	Engineer Level 4	134	Hr	91.06	12,202	
	Administrative	120	Hr	37.76	4,531	65,757
Travel & Living Allowance			LS		38,800	38,800
	Vortec Totals	**1,670**				**$184,631**
Construction Contractor						
Labor	Laborer	220.00	Hr	27.20	5,984	
	Crain, Backhoe Operator	220.00	Hr	32.87	7,231	
	Carpenter	110.00	Hr	30.35	3,339	
	Pipefitter	440.00	Hr	35.65	15,686	
	Electrical	440.00	Hr	32.31	14,216	
	Millwright	440.00	Hr	32.57	14,331	

Table D-6. Cold and Hot Start-up Labor Cost (Continued)

Category	Description	Qty	UM	Rate	Cost	Sub Total
Labor	Millwright	440.00	Hr	31.39	13,812	$ 74,599
Small Tools	Small Tools, Laborer	220.00	Hr	1.07	235	
Small Tools	Small Tools, Operator	220.00	Hr	1.07	235	
	Small Tools, Carpenter	110.00	Hr	1.07	118	
	Small Tools, Pipefitter	440.00	Hr	1.07	471	
	Small Tools, Electrician	440.00	Hr	1.07	471	
	Small Tools, Millwright	880.00	Hr	1.07	942	$ 2,472
Construction Contractor Totals		**2,310**			**Total**	**$ 77,070**
Total Hours		**6,329**			**Total Cost**	**$ 476,151**

Table D-7. Cold Start-up Consumables Cost

Item	Description	Qty	UM	Unit Cost	Total	Potential Supplier	Note
C1	Glass Cullet	211	Tons	125.00	$26,400	Allwaste Recycling, Inc	1,200 Lb/Hr x352 Hr.
C2	Natural Gas	55,440	CCF	0.35	$19,404	TBD, Local	55 CCF/Hr x 1,008 Hr
C3	Electricity	1,209.600	kWH	0.75	$90,720	TBD, Local	1,200 Kw x 1,008 Hr
C4	Liquid Oxygen	8,800	CCF	0.40	$3,520	Air Products & Chemicals Inc.	25 CCF/Hr x 352 Hr.
C5	Propylene Glycol (Dowfrost HD)	600	Gal	5.00	$3,000	Dow	CMS™ Start-up
C6	Cooling Water Chemicals	2	drums	750.00	$1,500		Allowance
C7	Calibration Gas Cylinders	1	LS	3,233.00	$3,233	Altech	CMS™ Start-up
C8	Instruments	1	LS	1,000.00	$1,000		Replacement Allowance
C9	Trisodium Phosphate (TSP)	100	Lbs	1.07	$107		
C10	Utility hoses	10	Each	227.00	$2,270	Grainger	
C11	Add start-up strainers to pumps	1	LS	635.00	$635	McMaster Carr	Includes 1 Ea: Strainer, Butterfly Valve, Gate Valve, Nipple, Pipe Cap. Spool Section with 150# flanges
C12	Drum Pump	1	Each	250.00	$250	Grainger	
C13	Office Supplies	2	Mo	3,333.00	$6,667		$40,000 / 12 Mo = $3,333
				Total	**$158,706**		

Table D-8. Hot Start-up Consumables Cost

Table D-8. Hot Start-up Consumables Cost

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Item	Description	Qty	UM	Unit Cost	Total	Potential Supplier	Note
H1	Soda Ash	18	Tons	200.00	$3,528	Van Waters & Rogers	#, 105 Lb/Hr x 336 Hr.
H2	Limestone	29	Tons		$635	Van Waters & Rogers	#, 171 Lb/Hr x 336 Hr.
H3	Lithium Carbonate	18	Tons	2000.00	$36,000		#, 105 Lb/Hr x 336 Hr.
H4	Natural Gas	18,480	CCF	0.35	$6,468	TBD, Local	#, 55 CCF/Hr x 336 Hr.
H5	Electricity	403,200	kWH	0.075	$30,240	TBD, Local	#, 1,500 KW installed x .08 operating factor = 1,200 Kw x 336 Hr.
H6	Liquid Oxygen	8,400	CCF	0.40	$3,360	Air Products & Chemicals Inc.	#, 25 CCF/Hr x 336 Hr.
H7	Caustic Soda	5,578	Gal	1.50	$8,366	Van Waters & Rogers	#, 16.6 GPH x 336 Hr.
H8	Sodium Hypochlorite	1,680	Lb	2.75	$4,620		#, 5 Lb/Hr x 336 Hr.
H9	Cooling Water Chemicals	1	Drums	1,000.00	$1,000		1 Drum / mo.
H10	Polymer	1	Drum	1,000.00	$1,000		1 Drum / Mo x 36 Mo.
H11	Sulfuric Acid	3	Tote	1,050.00	$3,150		(1) 300 Gal Tote/ Wk
H12	Calibration Gas Cylinders	1	LS	6,535.00	$6,535	Altech	
H13	Filter Precoat	1,680	Lb	0.25	$420		120 Lb/Day x 14 Days
H14	Tyvek Overall Suits	1,500	Each	5.22	$7,830	McMaster Carr	30 day supply for 50
H15	Tyvek Boot Covers	1,500	Each	0.96	$1,440	McMaster Carr	30 day supply for 50
H16	Safety Glasses	35	Each	5.87	$206	McMaster Carr	
H17	Safety Overglasses	15	Each	7.57	$114	McMaster Carr	
H18	Traditional Hardhats	50	Each	42.95	$2,148	McMaster Carr	
H19	Half face Respirators (w cartridges)	50	Each	42.46	$2123	McMaster Carr	
H20	Banded Ear Plugs	50	Each	3.64	$182	McMaster Carr	
H21	Office Supplies	2	Week	670.00	$1,340		$40,000 / 52 Wk = $670
				Total	**$120,705**		

Note #: 24 Hr/Day, 7 days/Week for 2-weeks.

2.0 OPERATING COSTS

Operational energy cost presented in Table D-11 and operational consumables cost is presented in Table D-12. These Operating Cost are provided to assist Fluor Daniel Fernald in establishing an integrated Operational Cost for the facility. No operating cost are included in Project Cost Summary in Table D-2. Table D-10 presents the expected lifetime of the equipment provided.

2.1 OPERATIONS LABOR

A preliminary plant staffing list has been provided to assist in forecasting operational cost. Staffing is based on operating the vitrification system 24 hours per day 7 days per week for 40 weeks /year at 90% operational efficiency. These data are consistent with commercial CMS™ plant operations and Vortec Corporation and Foster Environmental Corporation support is from their home site locations. any unplanned travel and living expenses for Vortec Corporation and Foster Environmental Corporation will be additive to the cost shown in Table D-9.

Operational staffing in Table D-9 is for two 12-hour shifts with 4-days on, then 4-days off. The 4-days on and 4-days off plan keep repeating for the duration of the project. A total of 4 operational shifts are required to support the 4-4 plan. The shifts are 1A, 1B, 2A, and 2B with each assigned person working 48 hours per week. Support personnel identified as existing FDF staff are planned to work their normally scheduled shift. Certain personnel listed in the Operational Management & Support category work on both shifts but work 8-hours/day 6-days per week.

Table D-9. Operational Labor Cost

No.	Position	Labor Category	Assigned Station	Shift	Rate	Hr./ Wk	Cost per Week
	Operational Staff						
1	Control Room Operator 1	Hourly	Control Room	1A		48	
2	Control Room Operator 2	Hourly	Control Room	1B		48	
3	Control Room Operator 3	Hourly	Control Room	2A		48	
4	Control Room Operator 4	Hourly	Control Room	2B		48	
5	Rover, Batch & Blend & CMS System 1	Hourly	CMS Process Area	1A		48	
6	Rover, Batch & Blend & CMS System 2	Hourly	CMS Process Area	1B		48	
7	Rover, Batch & Blend & CMS System 3	Hourly	CMS Process Area	2A		48	
8	Rover, Batch & Blend & CMS System 4	Hourly	CMS Process Area	2B		48	
9	Feed Processing Operator 1	Hourly	Feed Processing Area	1A		48	
10	Feed Processing Operator 2	Hourly	Feed Processing Area	1B		48	
11	Feed Processing Operator 3	Hourly	Feed Processing Area	2A		48	
12	Feed Processing Operator 4	Hourly	Feed Processing Area	2B		48	
13	Product Handling Operator / Rover 1	Hourly	Product Handling Area / Roving	1A		48	
14	Product Handling Operator / Rover 2	Hourly	Product Handling Area / Roving	1B		48	
15	Product Handling Operator / Rover 3	Hourly	Product Handling Area / Roving	2A		48	
16	Product Handling Operator / Rover 4	Hourly	Product Handling Area / Roving	2B		48	
17	Electrical Maintenance	Hourly	Maintenance Area	1A/1B		48	

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Table D-9. Operational Labor Cost (Continued)

No.	Position	Labor Category	Assigned Station	Shift	Rate	Hr./ Wk	Cost per Week
18	Electrical Maintenance	Hourly	Maintenance Area	2A/2B		48	
19	Mechanical Maintmance	Hourly	Maintenance Area	1A/1B		48	
20	Mechanical Maintmance	Hourly	Maintenance Area	2A/2B		48	
21	General Purpose Operator 1	Hourly	Rover, Sick/ Absence/ Vacation Sub	1A		48	
22	General Purpose Operator 2	Hourly	Rover, Sick/ Absence/ Vacation Sub	1A		48	
23	General Purpose Operator 3	Hourly	Rover, Sick/ Absence/ Vacation Sub	1B		48	
24	General Purpose Operator 4	Hourly	Rover, Sick/ Absence/ Vacation Sub	1B		48	
25	General Purpose Operator 5	Hourly	Rover, Sick/ Absence/ Vacation Sub	2A		48	
26	General Purpose Operator 6	Hourly	Rover, Sick/ Absence/ Vacation Sub	2A		48	
27	General Purpose Operator 7	Hourly	Rover, Sick/ Absence/ Vacation Sub	2B		48	
28	General Purpose Operator 8	Hourly	Rover, Sick/ Absence/ Vacation Sub	2B		48	
			Sub Total			**1,344**	$
	Operational Management & Support						
1	Plant Operations Manager 1	Salaried	Operational Office	1A		48	
2	Plant Operations Manager 2	Salaried	Operational Office	1B		48	
3	Plant Operations Manager 3	Salaried	Operational Office	2A		48	
4	Plant Operations Manager 4	Salaried	Operational Office	2B		48	
5	QA Engineer 1	Salaried	Operational Office	1A		48	
6	QA Engineer 2	Salaried	Operational Office	1B		48	
7	QA Engineer 3	Salaried	Operational Office	2A		48	
8	QA Engineer 4	Salaried	Operational Office	2B		48	
9	Safety & Health Officer (SHO) 1	Salaried	Operational Office	1A		48	
10	Safety & Health Officer (SHO) 2	Salaried	Operational Office	1B		48	
11	Safety & Health Officer (SHO) 3	Salaried	Operational Office	2A		48	
12	Safety & Health Officer (SHO) 4	Salaried	Operational Office	2B		48	
13	Environmental Compliance Engineer 1	Salaried	Operational Office	1A/1B		48	
14	Environmental Compliance Engineer 2	Salaried	Operational Office	2A/2B		48	
15	Secretary / CMA 1	Hourly	Operational Office	1A		48	
16	Secretary / CMA 2	Hourly	Operational Office	1B		48	
17	Secretary / CMA 3	Hourly	Operational Office	2A		48	
18	Secretary / CMA 4	Hourly	Operational Office	2B		48	
19	Material Control & Waste Mgmt Coordinator 1	Hourly	Operational Office	1A/1B		48	
20	Material Control & Waste Mgmt Coordinator 2	Hourly	Operational Office	2A/2B		48	
21	Radiation Control / Health Physics Technician 1	Hourly	Operational Office	1A/1B		48	
22	Radiation Control / Health Physics Technician 2	Hourly	Operational Office	2A/2B		48	
23	Receiving/Shipping Operator 1	Hourly	Operational Office	1A/1B		48	
24	Receiving/Shipping Operator 2	Hourly	Operational Office	2A/2B		48	
25	Supervisor 1	Salary	Oper. Office, Vacation/Absence Sub	1A/1B		48	
26	Supervisor 2	Salary	Oper. Office, Vacation/Absence Sub	2A/2B		48	
			Sub Total			**1,248**	$

Table D-9. Operational Labor Cost (Continued)

No.	Position	Labor Category	Assigned Station	Shift	Rate	Hr./Wk	Cost per Week
	Support from Existing FDF Staff						
1	Process Engineer 1	Salaried	Existing FDF Office	1		20	0
2	Design Engineering 1	Salaried	Existing FDF Office	1		20	0
3	Secretary / CMA 1	Hourly	Existing FDF Office	1		20	0
4	Procurement 1	Salaried	Existing FDF Office	1		20	0
5	Plant Mechanic 1	Hourly	Existing FDF Maintenance Office	1		20	0
6	Plant Electrician 1	Hourly	Existing FDF Maintenance Office	1		20	0
7	Site Administrator/Human Resources 1	Hourly	Operational Office	1		20	0
8	Security / Plant Protection 1	Hourly	Operational Office	1		20	0
9	Security / Plant Protection 2	Hourly	Operational Office	2		20	0
10	Security / Plant Protection 3	Hourly	Operational Office	Swing		20	0
			Sub Total			**200**	**$**
	Subcontracted Operational Support During Plant Operation						
1	Principle Engineer	Salaried	FWEC, Knoxville, TN	1	115.00	16	1,840
2	Senior Engineer	Salaried	FWEC, Knoxville, TN	1	100.00	8	800
3	Senior Engineer	Salaried	FWEC, Knoxville, TN	1	100.00	16	1,600
4	Process Engineer	Salaried	Vortec Corp., Collegeville, PA	1	105.00	16	[illegible]
5	Glass Technologist	Salaried	Vortec Corp., Collegeville, PA	1	95.00	8	[illegible]
6	Operational Process Engineer	Salaried	Vortec Corp., Collegeville, PA	1	95.00	16	1,520
			Sub Total			**412**	**$ 8,200**

2.2 EXPECTED EQUIPMENT LIFETIME

Expected lifetime for equipment is shown in Table D-10. Lifetime noted as > 36 mo. indicates that the equipment will last longer than the current planed operational span of three years. Regular maintenance will be required on all equipment items to reach its maximum useful life.

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Table D-10. Expected Equipment Lifetime

Item	Item Description	Equip ID	Lifetime	Item	Item Description	Equip ID	Lifetime
1	Holding Tank Transfer Pump	P-1	> 36 Mo	43	Heat Exchanger	HTX-2	> 36 Mo
2	TTA Transfer Pump	P-1	> 36 Mo	44	Oxidizing Recycle Pump	P-10A, -10B	> 36 Mo
3	Condensate Hold-up Tank	TK-1	> 36 Mo	45	Water Hold-up Tank Pump	P-3	> 36 Mo
4	Centrifuge	CENT-1, -2	> 36 Mo	46	Water Hold-up Tank Pump	P-3	> 36 Mo
5	Dryer Screw	DS-1, -2	> 36 Mo	47	SOX Scrubber Sump Pumps	P-4A, P-4B	> 36 Mo
6	Thermal Fluid Heater	HTR-1	> 36 Mo	48	NOX Conditioner Sump Pumps	P-5A, P-5B	> 36 Mo
7	Heat Exchanger	HTX-1	> 36 Mo	49	Urea Injection Pumps	P-6A, P6B	> 36 Mo
8	Nitrogen Supply	NIT-1	> 36 Mo	50	Caustic Stotage Tank Pumps	P-7A, P7B	> 36 Mo
9	Condesate Hold-up Tank	TK-2	> 36 Mo	51	SO2 Scrubber	S-1	> 36 Mo
10	Pneumatic Conveying System	PCS-1	> 36 Mo	52	NOX Scrubber	S-2	> 36 Mo
11	Hammer Mill	BM-1	> 36 Mo	53	Sump recirculation Tank	SMP-1, -2	> 36 Mo
12	Additives Storage Bins	DA-1, -2, -3	> 36 Mo	54	Urea Storage Tank	TK-4	> 36 Mo
13	Additives Storage Support	DA-x	> 36 Mo	55	Radon Degassification Tank	TK-3	> 36 Mo
14	Dry Feed Storage Hopper	DF-1, -2, -3	> 36 Mo	56	Caustic Storage Tank	TK-5	> 36 Mo
15	Feed Blender	FB-1	> 36 Mo	57	Baghouse Transfer Screw	TSC-4	> 36 Mo
16	Feed Sampling System	FSS-1	> 36 Mo	58	Water Sampling System	SS-1	> 36 Mo
17	Dry Feed Metering Screw	MS-1, -2, -3, -4, -5	> 36 Mo	59	Water Treatment Package	WT-1	> 36 Mo
18	Feed Blender	SB-1	> 36 Mo	60	I&C Equip	I&C-1	> 36 Mo
19	Loss-in- Weight Feeder	SC-1	> 36 Mo	61	Air Compressor	AC-1	> 36 Mo
20	CRV Reactor System	CRV-1	> 36 Mo	62	Caustic Stotage Tank	TK-3	> 36 Mo
21	Dry Feed Transporter	TSC-1, -2, -3	> 36 Mo	63	Washdown Water Return Tank	TK-6	> 36 Mo
22	CMS™ Tower	VST-1	> 36 Mo	64	Washdown Return Water Pump	P-11	> 36 Mo
23	Cyclone Melter System	CMS-1	> 36 Mo	65	Cooling Tower	CT-1	> 36 Mo
24	CMS™ Refractory	-	1-year	66	Oxygen Enrichment System	O2-1	> 36 Mo
25	CRV Reactor System	CRV-1	> 36 Mo	67	HEPA Filter Vacuum	VAC-1	> 36 Mo
26	CRV Refractory	-	1-year	68	Radon Control System	BOP-x	> 36 Mo
27	Sep. Res./ Glass Chnl Sys	SR/GC-1	> 36 Mo	69	Process Piping	BOP-x	> 36 Mo
28	SR/GC Refractory	-	1-year	70	Electrical, Distribution	BOP-x	> 36 Mo
29	Lined Duct Refractory	-	1-year	71	Electrical, Back-up Generator	BOP-x	> 36 Mo
30	Air Heater System	VAH-1	> 36 Mo	72	Control Room Furnishings	BOP-x	> 36 Mo
31	Conveyors	C-1 ,-2	> 36 Mo	73	Process Buildings	BOP-x	> 36 Mo
32	Heat Exchanger	HTX-3, HTX-4	> 36 Mo	74	HVAC (Equip, Ductwork, Vents)	BOP-x	> 36 Mo
33	Drag Conveyor Recycle Pump	P-9	> 36 Mo	75	Electrical	BOP-x	> 36 Mo
34	Quench Tank / Drag Conveyor	QT-2	> 36 Mo	76	HVAC	BOP-x	> 36 Mo
35	Glass Product Sampling Sys.	SS-2	> 36 Mo	77	Viewing Portal	BOP-x	> 36 Mo
36	Jib Crain	JC-1	> 36 Mo	78	Control Room Furnishings	BOP-x	> 36 Mo
37	APC System	APC-1	> 36 Mo	79	Process Buildings	BOP-x	> 36 Mo
38	Dust Collector	BH-1	> 36 Mo	80	HVAC (Equip, Ductwork, Vents)	BOP-x	> 36 Mo
39	NOx Scrubber Chiller	CH-1	> 36 Mo	81	Electrical	BOP-x	> 36 Mo
40	Evaporative Cooler	EC-1	> 36 Mo	82	HVAC	BOP-x	> 36 Mo
41	Combustion Air Supply Fan	FAN-1	> 36 Mo	83	Viewing Portal	BOP-x	> 36 Mo
42	Induced draft Booster Fan	FAN-2	> 36 Mo	87			

2.3 OPERATIONAL ENERGY CONSUMPTION

An estimate energy consumption is provided in Table D-11. The energy required is based on the plant operating 24-hours per day, 7-days per week for 40-weeks at a 90% operational efficiency (70% availability).

Table D-11. Operational Energy Consumption

Item	Energy Item	Qty	UM	Unit Cost	Cost	Note
1	Natural Gas	997,920	CCF	0.35	$349,272	##, 55 CCF/Hr x 18,144 Hr.
2	Electricity	21,772,800	kWH	0.075	$1.632,960	##, 1,500 KW installed x .08 operating factor = 1,200 Kw x 18,144 Hr.
				Total	**$1,982,232**	

Note ##: 24 hr/day, 7 days/week x 40-weeks x 0.9 efficiency x 3-Years = 18,144 operational hours.

2.4 OPERATIONAL CONSUMABLE CONSUMPTION

Three additives are used in Vortec's vitrification system in processing Silo 1 & 2 residues. The amount of consumables required is provided in Table D-12. The operational consumable consumption is based on the plant operating 24-hours per day, 7-days per week for 40-weeks at a 90% operational efficiency (70% availability).

Table D-12. Operational Consumables Consumption

Item	Description	Qty	UM	Unit Cost	Total Cost	Note
1	Soda Ash	952.6	Tons	200.00	$190,512	#, 105 Lb/Hr x 18,144 Hr.
2	Limestone	1,551.3	Tons	28.00	$43,737	#, 171 Lb/Hr x 18,144 Hr.
3	Lithium Carbonate	962.6	Tons	2,000.00	$1,905,200	#, 105 Lb/Hr x 18,144 Hr.
6	Liquid Oxygen	453,600	CCF	0.40	$181,440	#, 25 CCF/Hr x 18,144 Hr.
7	Caustic Soda	301,190	Gal	1.50	$451,786	#, 16.6 GPH x 18,144 Hr.
8	Sodium Hypochlorite	90,720	Lb	2.75	$249,480	#, 5 Lb/Hr x18,144 Hr.
9	Cooling Water Chemicals	36	Drum	1,000.00	$36,000	1 Drum/ Mo. X 36 Mo. = 36 Drums.
10	Sulfuric Acid	150	Tote	1,050.00	$157,500	(1) 300 gal Tote/ Wk x 50 Wk.Yr x 3 Yr = 150 Totes.

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Table D-12. Operational Consumables Consumption (Continued).

Item	Description	Qty	UM	Unit Cost	Total Cost	Note
11	Polymer	36	Drum	1,000.00	$36,000	1 Drum / Mo x 36 Mo.
12	Calibration Gas Cylinders	3	LS	6,535.00	$19,605	Yearly Calibration
13	Filter Precoat	126,000	Lb	0.25	$31,500	120 Lb/Day x 1,050 Days
14	Tyvek Overall Suits	53,250	Each	5.22	$277,965	1,065 day supply for 50
15	Tyvek Boot Covers	53,250	Each	0.96	$51,120	1,065 day supply for 50
16	Safety Glasses	35	Each	5.87	$206	100% Replacement
17	Safety Overglasses	15	Each	7.57	$114	100% Replacement
18	Traditional Hardhats	25	Each	42.95	$1,074	50% Replacement
19	Half face Respirators Cartridges	36	Mo	1,000	$36,000	$20/Mo/Mask x 50 Mask = $1,000
20	Banded Ear Plugs	150	Each	3.64	$546	3 years of 50 Ea. Yearly Replacement
21	Instruments	3	Year	1,000.00	$3,000	Yearly Replacement Allowance
22	Replacement parts for maintenance and spares.	3	Year	304,254.00	$912,762	Yearly Replacement Allowance 4% of Equipment Cost
23	Refractories	3	Year	241,350.00	$724,050	Yearly Replacement Allowance
24	Office Supplies	3	Year	40,000.00	$120,000	Yearly Allowance
				Total	**$5,429,297**	

Note #: 24 hr/day, 7 days/week x 40-weeks x 0.9 efficiency x 3-Years = 18,144 operational hours.

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SILO 1 AND SILO 2 PROOF OF PRINCIPLE PROJECT

ADDENDUM TO APPENDIX C

DATASHEETS FOR FULL-SCALE PLANT EQUIPMENT SELECTIONS

Contract No. FDF 98WO002241
Report No. BFA-4200-809-002
Fernald Submittal No. 40720-2241-C5-004

SUBMITTED TO:
Fluor Daniel Fernald
7400 Willey Rd.
Hamilton, OH 45013-9402

PREPARED BY:
Vortec Corporation
3770 Ridge Pike
Collegeville, PA 19426
Tel: (610) 489-2255
Fax: (610) 489-3185

Equip Data Sheet

2295

Equip Name	Air Compressor
Equip ID	AC-1
System:	BOP, Other Process Equip
Engineer	Craig Smith, FWEC
Sourse or Seller	Gardner Denver, Inc.
Contact and Phone No.	J.R. (Jim) Morton 423-577-3961 **Fax:** 423-573-3607
Quote Type	Supplier Budgetary
Equip Cost	$30,532.00
Quantity (Units)	1
Total Cost	$30,532.00

Narrative Provides clean, dry, compressed air to: Bag-house, Feed Sampling System, Glass Product Sampling System, Water Sampling System, Radon Degasification System, Emergency Water Tank, APC Package, Pneumatic Conveying System, Instrumentation, Miscl. Air Usage.

Features Include: 360 cfm at 100 psi, lubricated rotary screw, air cooled, direct motor drive, modulating vertical inlet valve, skid-mounted, moisture seperator and trap, air dryer, 240 gallon air reserve.

Dimension TBD

Sketch, or Catalog Cut

Gardner Denver Electra Saver II Model ST75 (EBMQL)

Equip Data Sheet

Equip Name	APC System		
Equip ID	APC-1	***System:***	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$453,434.00
Quantity (Units)			1
Total Cost			$453,434.00

Narrative The APC System is a full package from one dupplier that includes: EC-1, P-4A, P-4B, P-5A, P-5B, P-6A, P-7A, P-7B, P-19A, P-10B, S-1, S-2, SMP=1, SMP-2, TK-4, and TK-5.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet 2295

Equip Name	Dalamatic Dust Collector (Baghouse)		
Equip ID	BH-1	***System:***	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	DeGroff Process Equipment Co., Inc.		
Contact and Phone No.	M.C. DeGroff	901-377-0251	**Fax:** 901-377-0368
Quote Type	Supplier Budgetary		
Equip Cost			$32,843.00
Quantity (Units)			1
Total Cost			$32,843.00

Narrative The Dalamatic Dust Collector removes solids from the off-gas stream. Removed solids are recycled to the CMS™. 4 VF clearance under hopper, High Temp Seals, AccuRate Model 602 Volumetric Feeder. Dalamatic reverse jet fabric filter collector.
Envelop style filter bags. 968 SF of 16 oz. Polyester neddlefelt P-84 media suitable for high temp service. Single bank wide housing. 6 tiers of filters. Carbon steel construction w/ baked-on polyester powder finish inside and outside prior to assy.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Hammer Mill		
Equip ID	BM-1	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	M.C. DeGoff Process Equipment Co., Inc.		
Contact and Phone No.	M.C. DeGoff	901-377-0251	**Fax:** 901-377-0368
Quote Type	Supplier Budgetary		
Equip Cost			$17,769.00
Quantity (Units)			1
Total Cost			$17,769.00

Narrative The Hammer Mill is used to pulverize feed and mix additives prior to storage in the dry feed storage hopper.

Dimension TBD

Sketch, or Catalog Cut

Scot "Shredder-izer" Model SH 18" x 18"

Equip Data Sheet

2295

Equip Name	Radon Control System Duct		
Equip ID	BOP-x1	**System:**	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	TBD		
Contact and Phone No.	Lee Dilthey (FWENC)	423-481-8647	**Fax:**
Quote Type	Engineering Estimate		
Equip Cost			$6,869.00
Quantity (Units)			1
Total Cost			$6,869.00

Narrative For the base estimate, there are no changes to the existing Radon Control System (RCS) Equipment. Approximately 300 LF of duct has to be run from the new Commercial Scale Cyclone Melting System Building to the existing RCS Building.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Viewing Portal		
Equip ID	BOP-x2	***System:***	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	TBD
Contact and Phone No.	Lee Dilthey (FWENC) 423-481-8647 **Fax:**
Quote Type	Engineering Estimate
Equip Cost	$10,000.00
Quantity (Units)	1
Total Cost	$10,000.00

Narrative Viewing portal is in the wall behind the Glass Product Discharge Area and the End Product Handling Area. The forklift Operator uses the portal to view the lid removal operation.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Electrical (with Instrumentation)
Equip ID	BOP-x3
System:	BOP, Other Process Equip
Engineer	Craig Smith, FWEC
Sourse or Seller	TBD
Contact and Phone No.	Lee Dilthey (FWENC) 423-481-8647 **Fax:**
Quote Type	Engineering Estimate
Equip Cost	$570,860.00
Quantity (Units)	1
Total Cost	$570,860.00

Narrative Includes electrical for Service entrance, Electric Equip., Emergency System, Building Grounds, Lighting & Misc Power, Site Office & Storage,

No Installation Cost Included

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	Process Buildings
Equip ID	BOP-x4
System:	BOP, Other Process Equip
Engineer	Craig Smith, FWEC

Sourse or Seller	FWENC
Contact and Phone No.	Lee Dilthey (FWENC) 423-481-8647 **Fax:**
Quote Type	Engineering Estimate
Equip Cost	$36,000.00
Quantity (Units)	1
Total Cost	$36,000.00

Narrative Includes mandoors & hardware, F&I, Galv stairs, railings, etc

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

E 2295

Equip Name	Control Room Furnishings		
Equip ID	BOP-x5	*System:*	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	TBD
Contact and Phone No.	Lee Dilthey (FWENC) 423-481-8647 **Fax:**
Quote Type	Engineering Estimate
Equip Cost	$10,000.00
Quantity (Units)	1
Total Cost	$10,000.00

Narrative Furnishings for the control room.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	Process Piping
Equip ID	BOP-x6
System:	BOP, Other Process Equip
Engineer	Craig Smith, FWEC
Sourse or Seller	FWENC
Contact and Phone No.	Lee Dilthey (FWENC) 423-481-8647 **Fax:**
Quote Type	Engineering Estimate
Equip Cost	$142,084.00
Quantity (Units)	1
Total Cost	$142,084.00

Narrative Includes 12" Dai piping , 8" Dia piping, 4" Dia piping, 2.5" Dia piping, 2" dia piping, 1.5" Dia Piping, 1" dia Piping, and 1/2" dia Piping.

90 degree bends, 45 degree bends, Tees, Flanges, Gate valves, Check valves, solenoid valves, ball valves, reducers, threaded caps, Pneu Oper ContV are also included.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	Powered Roller Conveyor		
Equip ID	C-1	*System:*	Product Handling System
Engineer	Craig Smith, FWEC		

Sourse or Seller	Conveyor Systems & Engineering, Inc.		
Contact and Phone No.	Bob LoGiurato	847-593-2900	**Fax:** 847-593-2971
Quote Type	Supplier Budgetary		
Equip Cost			$38,272.00
Quantity (Units)			1
Total Cost			$38,272.00

Narrative The HD Chain-Driven Live Roller Conveyor is used to move the Glass Product Bins into/out of the Product Discharge Area. Conveyor Control System will index the bin to the lid removal stage, progress to the product discharge stage, return for re-lidding.
4.5" Dia x 1.25" thick wall tubing, 2" Dia shaft, 10 FPM Conveyance Speed. First 6' to be modified to allow for Fork Truck to pick-up / deliver Glass Product Bin. Heavy Duty supports at 5' o.c.

Dimension 57" / 62" W x 20' -0" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Powered Roller Conveyor
Equip ID	C-2
System:	Product Handling System
Engineer	Craig Smith, FWEC

Sourse or Seller	Conveyor Systems & Engineering, Inc.
Contact and Phone No.	Bob LoGiurato 847-593-2900 **Fax:** 847-593-2971
Quote Type	Supplier Budgetary
Equip Cost	$38,272.00
Quantity (Units)	1
Total Cost	$38,272.00

Narrative The HD Chain-Driven Live Roller Conveyor is used to move the Glass Product Bins into/out of the Product Discharge Area. Conveyor Control System will index the bin to the lid removal stage, progress to the product discharge stage, return for re-lidding.
4.5" Dia x 1.25" thick wall tubing, 2" Dia shaft, 10 FPM Conveyance Speed.
Heavy Duty supports at 5' o.c.

Dimension 57" / 62" W x 20' -0" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

E 2295

Equip Name	Centrifuge		
Equip ID	CENT-1	***System:***	Feed Prep
Engineer	Craig Smith, FWEC		

Sourse or Seller	Andritz-Ruthner, Inc.		
Contact and Phone No.	Kyle DeLon	817-465-5611	**Fax:** 817-468-3961
Quote Type	Supplier Budgetary		
Equip Cost			$344,912.00
Quantity (Units)			1
Total Cost			$344,912.00

Narrative The Centrifuges are used to dewater TTA slurry from its initial 10-30% solids content to 50% solids content. Solids output is directed into the Dryer Screws, liquid output is pumped back to the TTA, and Off-Gas is routed to the FD Fan.

The 200 HP motor drives a variable speed main drive (VFD). The 40 HP motor drives a variable speed backdrive (VFD).

Dimension TBD

Sketch, or Catalog Cut

Andriz Model D5LL

Equip Data Sheet

Equip Name	Centrifuge
Equip ID	CENT-2
System:	Feed Prep
Engineer	Craig Smith, FWEC
Sourse or Seller	Andritz-Ruthner, Inc.
Contact and Phone No.	Kyle DeLon 817-465-5611 **Fax:** 817-468-3961
Quote Type	Supplier Budgetary
Equip Cost	$344,912.00
Quantity (Units)	1
Total Cost	$344,912.00

Narrative The Centrifuges are used to dewater TTA slurry from its initial 10-30% solids content to 50% solids content. Solids output is directed into the Dryer Screws, liquid output is pumped back to the TTA, and Off-Gas is routed to the FD Fan.

The 200 HP motor drives a variable speed main drive (VFD). The 40 HP motor drives a variable speed backdrive (VFD).

Dimension TBD

Sketch, or Catalog Cut

Andriz Model D5LL

Equip Data Sheet

2295

Equip Name	NOx Scrubber Chiller		
Equip ID	CH-1	***System:***	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	Edwards Engineering Corp.		
Contact and Phone No.	Jorge Mulato	973-836-2800	**Fax:** 973-835-2805
Quote Type	Supplier Budgetary		
Equip Cost			$31,155.00
Quantity (Units)			1
Total Cost			$31,155.00

Narrative The Nox Scrubber Chiller is an Industrial Style Packaged Liquid Chiller that rejects 100,000 BTU/hr @ 25 Degree F LCT.

Features Include: Air cooled unit for outdoor instl, Model No. CE-20AHP, round design, dual pump, 130 gallon reservoir, 80 GPM

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Cyclone Melter System (CMS™)		
Equip ID	CMS-1	***System:***	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$1,095,751.00
Quantity (Units)			1
Total Cost			$1,095,751.00

Narrative The Cyclone Melter receives preheated batch from the CRV. The gas dynamics within the melter force the batch particles to the wall ehere rapid melting of the preheated batch occurs.

Vitrified product and hot gases exhaust from the melter to the seperator reservoir. This component is a water jackated steel shell of the cyclone melter.

Dimension TBD

Sketch, or Catalog Cut

See Layout Dwg

Equip Data Sheet 2295

Equip Name	Cyclone Melter System (CMS™) (Included with CMS-1)		
Equip ID	CMS-1-1	***System:***	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The Cyclone Melter receives preheated batch from the CRV. The gas dynamics within the melter force the batch particles to the wall ehere rapid melting of the preheated batch occurs.

Vitrified product and hot gases exhaust from the melter to the seperator reservoir. This component is a water jackated steel shell of the cyclone melter.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	CMS™ Refractory Insulation (Included with CMS-1)
Equip ID	CMS-1-100
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Located inside the CMS™. The refractory insulation is used between the steel walls and refractory.

Serves to control thermal heat loss between the refractory and steel shell. Also acts to control difference in thermal coefficients between refractory and steel wall.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	Hot Gas Piping (Included with CMS-1)
Equip ID	CMS-1-11
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation
Contact and Phone No.	R.K. Hnat 610-489-2255 **Fax:** 610-489-3185
Quote Type	Supplier Factored PO
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative Located on the CMS™ tower. The hot gas piping is used to connect various CMS™ components that transport hot gas.

Stainless Steel. Expansion joints are required.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	CMS™ Combustion Air Blower (Included with CMS-1)
Equip ID	CMS-1-2 ***System:*** Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Provides combustion air flow to the CMS™. Blower is equiped with a variable speed drove to control the combustion air.

Dimension 99.5" x 46" x 42.625"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	CMS™ Spring Hangers (Included with CMS-1)
Equip ID	CMS-1-3
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation
Contact and Phone No.	R.K. Hnat 610-489-2255 **Fax:** 610-489-3185
Quote Type	Supplier Factored PO
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative Used to mount the CMS™ to fixed supports to alleviate stress from thermal expansion.

Dimension 1/2" to 1-1/4"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name CMS™ View Ports (Included with CMS-1)

Equip ID CMS-1-4 **System:** Vortec Vitrification System

Engineer J. Santioanni, Vortec

Sourse or Seller Vortec Corporation

Contact and Phone No. R.K. Hnat 610-489-2255 **Fax:** 610-489-3185

Quote Type Supplier Factored PO

Equip Cost $0.00

Quantity (Units) 3

Total Cost $0.00

Narrative Used to visually inspect CMS™ safely when operational.

Dimension 3" OD a 2", 4" OD x 2"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	Combustion Air Filter (Included with CMS-1)
Equip ID	CMS-1-5
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Used at the inlet of the CMS™ combustion air blower to keep the inlet air clean.

Dimension 6" Dia x 34" long

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	Flame Safety Panel (Included with CMS-1)		
Equip ID	CMS-1-7	***System:***	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Controls the flow of natural gas to the roof burners.

Dimension 36" x 36" x 12"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

22295

Equip Name	CMS™ Refractory (Fired shapes) (Included with CMS-1)		
Equip ID	CMS-1-8	**System:**	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Located inside the CMS™ unit. The refractory is used to line and protect the CMS™ during poecessing.

Cast specifically to fit the CMS™.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	CMS™ Refractory (Balance) (Included with CMS-1)
Equip ID	CMS-1-9
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation
Contact and Phone No.	R.K. Hnat 610-489-2255 **Fax:** 610-489-3185
Quote Type	Supplier Factored PO
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative Located inside the CMS™ unit. The refractory is used to line and protect the CMS™ steel walls during poecessing.

Generic Industry Standard Shapes.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	CRV Reactor System		
Equip ID	CRV-1	***System:***	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$1,052,951.00
Quantity (Units)			1
Total Cost			$1,052,951.00

Narrative The Counter Rotating Vortex (CRV) Combustor is a well stirred reactor where the combustion and batch preheating occur simultaneously. Natural gas is combusted in the CRV and the premixed batch is injected axially into the CRV.

The batch materials are raised to temperature in the CRV. This component is a water jacketed steel sheel.

Dimension TBD

Sketch, or Catalog Cut

See Layout Dwg

Equip Data Sheet

Equip Name	CRV Flame Safety Panel (Included with CRV-1)
Equip ID	CRV-1-1
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec
Sourse or Seller	Vortec Corporation
Contact and Phone No.	R.K. Hnat 610-489-2255 **Fax:** 610-489-3185
Quote Type	Supplier Factored PO
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative Controls the flow of natural gas to the CMS™.

Dimension 36" x 36" x 12"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	CRV Natural Gas Control Skid (Included with CRV-1)		
Equip ID	CRV-1-2	***System:***	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A pre-piped Skid Assembly that contains the instrumentation and valving required to monitor the total gas flow to the CMS™.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	CRV Natural Gas Control Skid (Included with CRV-1-1)
Equip ID	CRV-1-3
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A pre-piped skid assembly that contains the instruments and valving required to monitor the total gas flow to the CMS™.

Dimension 126" x 29" x 74"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	CRV Refractory (Fired shapes) (Included with CRV-1)
Equip ID	CRV-1-4
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation
Contact and Phone No.	R.K. Hnat 610-489-2255 **Fax:** 610-489-3185
Quote Type	Supplier Factored PO
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative Located inside the CRV unit. The refractory is used to line and protect the CRV steel walls during poecessing.

Cast specifically to fit the CRV.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	CRV Refractory (Balance) (Included with CRV-1)
Equip ID	CRV-1-5 ***System:*** Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Located inside the CRV unit. The refractory is used to line and protect the CRV steel walls during poecessing.

Generic Industry Standard Shapes.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

~~229~~ 5

Equip Name	CRV Refractory Insulation (Included with CRV-1)
Equip ID	CRV-1-6
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Located inside the CRV. The refractory insulation is used between the steel walls and refractory.

Serves to control thermal heat loss between thre refractory and steel shell. Also acts to control difference in thermal coefficients between refractory and steel wall.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	CRV Combustor (Included with CRV-1)		
Equip ID	CRV-1-7	***System:***	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The Counter Rotating Vortex (CRV) combustor is a well stirred reactor where the combustion and batch preheat occurs simulataneously. Natural gas is combusted in the CRV and the premixed batch is injected axially into the VRV.

The batch mayreials are raised to melting temperature in the CRV. This component is the water jacketed steel shell of the CRV.

Dimension 70" Dia x 120"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

E 2295

Equip Name	CRV Seismic Restraints (Included with CRV-1)
Equip ID	CRV-1-8
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			4
Total Cost			$0.00

Narrative The seismic restraints are used to control lateral movement of the CRV Combustor.

Dimension 16.8" x 5" x 8.31"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	Cooling Tower		
Equip ID	CT-1	***System:***	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	Fergusen Equipment Co.		
Contact and Phone No.	Tom ____	423-524-1491	**Fax:** 423-637-8304
Quote Type	Supplier Budgetary		
Equip Cost			$27,956.00
Quantity (Units)			1
Total Cost			$27,956.00

Narrative Cooling Tower CT-1 is a Plate Heat Exchanger designed to reject 9,000,000 BTU/hr.

875 GPM, 125D-85D-78 Degrees. Operating weight 21,834 lbs, 12" 12 blade fan, 6" inlet/outlet connections, 316 ss plates on the APC Condensor.

Dimension 11'-10" L x 19'-10" W x 13' H

Sketch, or Catalog Cut

Marley No. NC6221

Equip Data Sheet

2295

Equip Name	Additive Storage Bin
Equip ID	DA-1
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Material Storage System		
Contact and Phone No.	Paul Allen	256-543-2467	**Fax:** 256-547-6725
Quote Type	Supplier Budgetary		
Equip Cost			$5,540.00
Quantity (Units)			1
Total Cost			$5,540.00

Narrative Dry Additive Hopper for CaO. 7' Dia with a useable capacity of 502 CF (Approx 53 tons). Installed outside the building attached to the steel support structure provided by the Dry Feed Hoppers.

3/16" Carbon Steel Plate

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Additive Storage Bin		
Equip ID	DA-2	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Material Storage System		
Contact and Phone No.	Paul Allen	256-543-2467	**Fax:** 256-547-6725
Quote Type	Supplier Budgetary		
Equip Cost			$5,540.00
Quantity (Units)			1
Total Cost			$5,540.00

Narrative Dry Additive Hopper for NaOH. 7' Dia with a useable capacity of 502 CF (Approx 53 tons). Installed outside the building attached to the steel support structure provided by the Dry Feed Hoppers.

3/16" Carbon Steel Plate

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Additive Storage Bin		
Equip ID	DA-3	*System:*	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Material Storage System		
Contact and Phone No.	Paul Allen	256-543-2467	**Fax:** 256-547-6725
Quote Type	Supplier Budgetary		
Equip Cost			$11,261.00
Quantity (Units)			1
Total Cost			$11,261.00

Narrative Dry Additive Hopper for LiOH. 7' Dia with a useable capacity of 502 CF (Approx 53 tons). Installed outside the building attached to the steel support structure provided by the Dry Feed Hoppers.

3/16" Stainless Steel Plate

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Additive Storage Support		
Equip ID	DA-x	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Material Storage System		
Contact and Phone No.	Paul Allen	256-543-2467	**Fax:** 256-547-6725
Quote Type	Supplier Budgetary		
Equip Cost			$44,649.00
Quantity (Units)			1
Total Cost			$44,649.00

Narrative Steel Support Structure for DA-1, DA-2, and DA-3.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Dry Feed Storage Hopper		
Equip ID	DF-1	**System:**	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Material Storage Systems, Inc.		
Contact and Phone No.	Paul Allen	256-543-2467	**Fax:** 256-547-6725
Quote Type	Supplier Budgetary		
Equip Cost			$6,101.00
Quantity (Units)			1
Total Cost			$6,101.00

Narrative The three Dry Feed Storage Hoppers are located on Floor 6. Each is 8' Dia with a usable capacity of 727 CF (Approx 330tons). Together they hold approx 7-days supply of feed for Vortec's Cyclone Melting System.

Constructed of 3/16" Carbon Steel Plate and weigh 5,528 lb each. There is a Structural Steel Support Structure to hold the 3 hoppers that weigh approx 57,018 lbs.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Dry Feed Storage Hopper		
Equip ID	DF-2	**System:**	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Material Storage Systems, Inc.		
Contact and Phone No.	Paul Allen	256-543-2467	**Fax:** 256-547-6725
Quote Type	Supplier Budgetary		
Equip Cost			$6,101.00
Quantity (Units)			1
Total Cost			$6,101.00

Narrative The three Dry Feed Storage Hoppers are located on Floor 6. Each is 8' Dia with a usable capacity of 727 CF (Approx 330tons). Together they hold approx 7-days supply of feed for Vortec's Cyclone Melting System.

Constructed of 3/16" Carbon Steel Plate and weigh 5,528 lb each. There is a Structural Steel Support Structure to hold the 3 hoppers that weigh approx 57,018 lbs.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

E 2295

Equip Name	Dry Feed Storage Hopper		
Equip ID	DF-3	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Material Storage Systems, Inc.		
Contact and Phone No.	Paul Allen	256-543-2467	**Fax:** 256-547-6725
Quote Type	Supplier Budgetary		
Equip Cost			$6,101.00
Quantity (Units)			1
Total Cost			$6,101.00

Narrative The three Dry Feed Storage Hoppers are located on Floor 6. Each is 8' Dia with a usable capacity of 727 CF (Approx 330tons). Together they hold approx 7-days supply of feed for Vortec's Cyclone Melting System.

Constructed of 3/16" Carbon Steel Plate and weigh 5,528 lb each. There is a Structural Steel Support Structure to hold the 3 hoppers that weigh approx 57,018 lbs.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Dryer Screw		
Equip ID	DS-1	***System:***	Feed Prep
Engineer	Craig Smith, FWEC		

Sourse or Seller	Svedala Industries, Inc.		
Contact and Phone No.	Dave Kleen	719-386-0242	**Fax:** 719-471-4469
Quote Type	Supplier Budgetary		
Equip Cost			$387,748.00
Quantity (Units)			1
Total Cost			$387,748.00

Narrative The Dryer Screw is used to dry the feed from 50% water content to 5% water content. It has a integral scale. One motor drives a reducer/drive unit which drives the multiple screws.

Dryer contains 662 gallons of Dowtherm Q Thermal Fluid. Matl flow rate 16,000 lb/hr, Matl input temp 50 deg F, Hot Oil transfer agent, Fluid input temp 550 deg F, Fluid discharge temp 480 deg F. Total fluid flow 815.4 GPM. Screw fluid volume 538 gal.

Dimension TBD

Sketch, or Catalog Cut

Svedala Holo-Flight, Model Q2420-6

Equip Data Sheet

2295

Equip Name	Dryer Screw		
Equip ID	DS-2	***System:***	Feed Prep
Engineer	Craig Smith, FWEC		

Sourse or Seller	Svedala Industries, Inc.		
Contact and Phone No.	Dave Kleen	719-386-0242	**Fax:** 719-471-4469
Quote Type	Supplier Budgetary		
Equip Cost			$387,748.00
Quantity (Units)			1
Total Cost			$387,748.00

Narrative The Dryer Screw is used to dry the feed from 50% water content to 5% water content. It has a integral scale. One motor drives a reducer/drive unit which drives the multiple screws.

Dryer contains 662 gallons of Dowtherm Q Thermal Fluid. Matl flow rate 16,000 lb/hr, Matl input temp 50 deg F, Hot Oil transfer agent, Fluid input temp 550 deg F, Fluid discharge temp 480 deg F. Total fluid flow 815.4 GPM. Screw fluid volume 538 gal.

Dimension TBD

Sketch, or Catalog Cut

Svedala Holo-Flight, Model Q2420-6

Equip Data Sheet

Equip Name	Evaporative Cooler (Incl w APC-1)
Equip ID	EC-1
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The Evaporative Cooler is a 2.5' ID, 316L ss vessel. Features Include: 316 ss construction, High Density Refractory Lining, Flanged inlet and outlet, 5 GPM max water flow, Automatic liquid flow control.

Dimension 2.5' ID x ___ H

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	Combustion Air Supply Fan
Equip ID	FAN-1
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	Charles F. Sexton Compant		
Contact and Phone No.	Charles Sexton	423-588-9691	**Fax:** 423-588-9692
Quote Type	Supplier Budgetary		
Equip Cost			$6,433.00
Quantity (Units)			1
Total Cost			$6,433.00

Narrative The Forced Draft Combustion Air Fan, Fan-1, is the primary Combustion Air Fan. It is a 500 SCFM Blower

Carbon steel casing, Alum Impellers, carbon steel shaft. Stationary internals, baseplate. Vellumoin/Felt shaft seals, 6" tube ooutlet, 3600 RPM, TEFC motor, Filter - Model No. FIL90011.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Induced Draft Booster Fan
Equip ID	FAN-2
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC
Sourse or Seller	DeGroff Process Equipment Co., Inc.
Contact and Phone No.	M.C. DeGroff 901-377-0251 **Fax:** 901-377-0368
Quote Type	Supplier Budgetary
Equip Cost	$2,649.00
Quantity (Units)	1
Total Cost	$2,649.00

Narrative The Induced Draft fan, Fan-2, is a Booster Fan. It is an American Fan Co. AF Radial Wheel Blower.

Features Include: 316 ss for all airstream contact surfaces, flanged inlet, flanged outlet, drain connection, drive guard system, and variable frequency controller.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Feed Blender
Equip ID	FB-1
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC
Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc
Contact and Phone No.	Keith Holt 800-725-7272 **Fax:** 817-926-4113
Quote Type	Supplier Budgetary
Equip Cost	$45,262.00
Quantity (Units)	1
Total Cost	$45,262.00

Narrative The horizontal ribbon type feeder is located on thr 5th floor.

Features Include: 1) 3/16" T316 ss steel plate body, 46" x 92", 2) 3/8" T316 ss steel end plates, 3)12 ga. Gasketed cover assy, 4) 6" Dia T316 ss steel solid mainshaft w/ a continuous double ribbon agitator, 5) 10" pneumatic actuated slide gate discharge.

Dimension TBD

Sketch, or Catalog Cut

Hayes & Stolz HR86 SSC, Dyan Air Conv Sys F-1500

Equip Data Sheet

Equip Name	Feed Hopper (Included with PSC-1)		
Equip ID	FH-1	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Smoot Co.		
Contact and Phone No.	Jeffery P. Pitts	913-362-1710	**Fax:** 913-362-7863
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The Feed Hpooer collects the material from Hammer Mill BM-1 and feeds it to the Pneumatic Conveying System PSC-1

Cost included with PCS-1

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Feed Sampling System
Equip ID	FSS-1
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Bristol Equipment Company
Contact and Phone No.	C.F. Phalen 630-553-7161 **Fax:** 630-553-5981
Quote Type	Supplier Budgetary
Equip Cost	$6,467.00
Quantity (Units)	1
Total Cost	$6,467.00

Narrative The Feed Sampling System samples the feed between the Pneumatic Conveying System Smoot Dense Phase Transmitter and the Dry Feed Storage Hoppers.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Thermal Fluid Heater		
Equip ID	HTR-1	***System:***	Feed Prep
Engineer	Craig Smith, FWEC		

Sourse or Seller	GTS Energy, Inc.		
Contact and Phone No.	Brett Hartley	770-801-8884	**Fax:** 770-801-8885
Quote Type	Supplier Budgetary		
Equip Cost			$229,228.00
Quantity (Units)			1
Total Cost			$229,228.00

Narrative The Thermal Fluid Heating System is used to heat the Dowtherm Q Fluid before it is circulated through the Dryer Screws 1,000 gal expansion tank w/ tank tower. 2,000 gal drain tank. Shell & tube type condensor..

Two coil. 3-pass, forced circulation heat transfer systemm 12.0 MMBtu/hr capacity. Fully modulated burner with combustion air blower and 20 HP motor. FM approved gas train and flame safety system. Thermal Fluid Pump and motor, 100 HP.

Dimension 60VF Exhaust Stack

Sketch, or Catalog Cut

GTS DH-V-40

Equip Data Sheet

2295

Equip Name	Heat Exchanger		
Equip ID	HTX-1	**System:**	Feed Prep
Engineer	Craig Smith, FWEC		

Sourse or Seller	Enviro-Systems, Inc.		
Contact and Phone No.	David M. Hensley	423-966-2033	**Fax:** 423-966-2038
Quote Type	Supplier Budgetary		
Equip Cost			$19,961.00
Quantity (Units)			1
Total Cost			$19,961.00

Narrative The Dryer Screw Vapor Heat Exchanger condensates the steam vapor coming off the dryer screws. Condensate goes to the Dryer Screw Heat Exchanger Condensate Hold-up Tank, Tank TK-2.

Shell & Tube-Type Heat Exchanger to condense 10,000 lb/hr steam @ 212 deg F (Approx 1500 GPM water @ 85 deg F), ss type 394 tubes, all other materials carbon steel, ASME Section VIII Div I TEMA "C".

Dimension 18" Dia x 7' Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name Heat Exchanger

Equip ID HTX-2 **System:** Air Pollution Control System

Engineer Craig Smith, FWEC

Sourse or Seller Paul Muller Company

Contact and Phone No. Lee Dilthey (FWENC) 423-481-8647 **Fax:**

Quote Type Factored Quote

Equip Cost $6,788.00

Quantity (Units) 1

Total Cost $6,788.00

Narrative The Sox Scrubber Sump Water Heat Exchanger is a Water-Water Heat Exchanger used to cool the Sox Scrubber Sump stream.

Similar to Muller Accu-Therm Heat Exchanger, Model AT40M HV, F-20 frame, 316 ss plates, NBR Gaskets, 52" L x 27" W x 68" H, 304 ss shroud, shipping wt. 2,655 lb, 125 G{M, 130 Degree in, 90 Degree out.

Dimension 52" L x 27" W x 68" H

Sketch, or Catalog Cut

Sim to Mueller Accu-Therm AT40M HV

Equip Data Sheet

2295

Equip Name	Drag Quench Water Heat Exchanger		
Equip ID	HTX-3	**System:**	Product Handling System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TBD		
Contact and Phone No.	Lee Dilthey (FWENC)	423-481-8647	**Fax:**
Quote Type	Factored Supplier Budgetary		
Equip Cost			$6,710.00
Quantity (Units)			1
Total Cost			$6,710.00

Narrative The Drag-Flight Quench Water Heat Exchanger, HTX-3, is a Water-Water Heat Exchanger used to cool the glass frit.

Similar to Muller Accu-Therm Heat Exchanger Model AT40M HV, F-20 Frame, 315 ss plates, NBR Gaskets, 52" L x 27" W x 68 " H, 304 ss shroud, 130 Degree in, 90 Degree out.

Dimension 52" L x 27" W x 68" H

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	DF Vapor Heat Exchanger
Equip ID	HTX-4
System:	Product Handling System
Engineer	Craig Smith, FWEC

Sourse or Seller	Enviro-Systems, Inc.
Contact and Phone No.	David M. Hensley 423-966-2033 **Fax:** 423-966-2038
Quote Type	Supplier Budgetary
Equip Cost	$6,710.00
Quantity (Units)	1
Total Cost	$6,710.00

Narrative The Drag-Flite Vapor Heat Exchanger is a Steam Condensor used to cool the steam generated when cooling the glass frit.

Shell & Tube-Type Heat Exchanger. 18" Dia x 5' Long. Condenses 600 lb/hr steam @ 212 Degree F (Approx 100 GPM water @ 85 Degree F). SS type 304 tubes, All other materials carbon steel, ASME Section VIII Div I TEMA "C".

Dimension 18" Dia x 5' Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	I&C (PLC Programming)		
Equip ID	I&C-1	***System:***	Instrumentation & Control
Engineer	Craig Smith, FWEC		

Sourse or Seller	TBD		
Contact and Phone No.	Lee Dilthey (FWENC)	423-481-8647	**Fax:**
Quote Type	Engineering Estimate		
Equip Cost			$174,700.00
Quantity (Units)			1
Total Cost			$174,700.00

Narrative LS estimate for I&C Equipment and 350 hours for Programming & PLC Operation included with Installation Cost.

Dimension N/A

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	Inlet Hopper with Spreader		
Equip ID	IH-1	***System:***	Feed Prep
Engineer	Craig Smith, FWEC		

Sourse or Seller	Svedala Industries, Inc.		
Contact and Phone No.	Dave Kleen	719-386-0242	**Fax:** 719-471-4469
Quote Type	Supplier Budgetary		
Equip Cost			$5,620.00
Quantity (Units)			1
Total Cost			$5,620.00

Narrative The collects the material from the Centrifuge and then feeds it to the Dryer Screw.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Inlet Hopper with Spreader
Equip ID	IH-2
System:	Feed Prep
Engineer	Craig Smith, FWEC
Sourse or Seller	Svedala Industries, Inc.
Contact and Phone No.	Dave Kleen 719-386-0242 **Fax:** 719-471-4469
Quote Type	Supplier Budgetary
Equip Cost	$5,620.00
Quantity (Units)	1
Total Cost	$5,620.00

Narrative The collects the material from the Centrifuge and then feeds it to the Dryer Screw.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Jib Crain		
Equip ID	JC-1	***System:***	Product Handling System
Engineer	Craig Smith, FWEC		

Sourse or Seller	BCH Crain & Hoist. Inc.		
Contact and Phone No.	Bill Countiss	800-262-0331	**Fax:** 205-916-0329
Quote Type	Supplier Budgetary		
Equip Cost			$22,365.00
Quantity (Units)			1
Total Cost			$22,365.00

Narrative The 1-Ton remotely operated jib crain is located in the product discharge area. It is used to remove/install the lid on the Glass Product Bin.

Jib crain will have a ten foot boom and a one ton wire rope hoist with motorized troiley and remotely controlled.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Dry Feed Metering Screw
Equip ID	MS-1
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc
Contact and Phone No.	Keith Holt 800-725-7272 **Fax:** 817-926-4113
Quote Type	Supplier Budgetary
Equip Cost	$8,892.00
Quantity (Units)	1
Total Cost	$8,892.00

Narrative Dry Feed Metering Screw, MS-1, feeds out of the Dry Feed Storage Hopper, DF-1.

Approx 4" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Dimension Approx 4" x 1.5" x 7'-3" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Dry Feed Metering Screw
Equip ID	MS-2
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc		
Contact and Phone No.	Keith Holt	800-725-7272	**Fax:** 817-926-4113
Quote Type	Supplier Budgetary		
Equip Cost			$8,892.00
Quantity (Units)			1
Total Cost			$8,892.00

Narrative Dry Feed Metering Screw, MS-2, feeds out of the Dry Feed Storage Hopper, DF-2.

Approx 4" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Dimension Approx 4" x 1.5" x 7'-3" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Dry Feed Metering Screw		
Equip ID	MS-3	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc		
Contact and Phone No.	Keith Holt	800-725-7272	**Fax:** 817-926-4113
Quote Type	Supplier Budgetary		
Equip Cost			$8,892.00
Quantity (Units)			1
Total Cost			$8,892.00

Narrative Dry Feed Metering Screw, MS-3, feeds out of the Dry Feed Storage Hopper, DF-3.

Approx 4" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Dimension Approx 4" x 1.5" x 7'-3" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Dry Feed Metering Screw
Equip ID	MS-4
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc
Contact and Phone No.	Keith Holt 800-725-7272 **Fax:** 817-926-4113
Quote Type	Supplier Budgetary
Equip Cost	$9,509.00
Quantity (Units)	1
Total Cost	$9,509.00

Narrative Dry Additive Meetering Screw, MS-4, feeds out CAO from thr Dry Additives Storage Hopper DA-1.

Approx 3" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Dimension Approx 3" x 1.5" x 7'-3" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Dry Feed Metering Screw
Equip ID	MS-5
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc
Contact and Phone No.	Keith Holt 800-725-7272 **Fax:** 817-926-4113
Quote Type	Supplier Budgetary
Equip Cost	$9,509.00
Quantity (Units)	1
Total Cost	$9,509.00

Narrative Dry Additive Meetering Screw, MS-4, feeds out NaOH from thr Dry Additives Storage Hopper DA-2.

Approx 3" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 25 RPM with a varispeed controller.

Dimension Approx 3" x 1.5" x 7'-3" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Dry Feed Metering Screw		
Equip ID	MS-6	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc		
Contact and Phone No.	Keith Holt	800-725-7272	**Fax:** 817-926-4113
Quote Type	Supplier Budgetary		
Equip Cost			$12,204.00
Quantity (Units)			1
Total Cost			$12,204.00

Narrative Dry Additive Meetering Screw, MS-4, feeds out LiOH from thr Dry Additives Storage Hopper DA-3.

Approx 3" x 1.5" x 7'-3" Long, 316 stainless steel tubular feeder with a 1 HP drive at 35 RPM with a varispeed controller.

Dimension Approx 3" x 1.5" x 7'-3" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Nitrogen Supply System		
Equip ID	NIT-1	*System:*	Feed Prep
Engineer	Craig Smith, FWEC		

Sourse or Seller	TBD		
Contact and Phone No.	Lee Dilthey (FWENC)	519-885-5513	**Fax:**
Quote Type	Engineering Estimate		
Equip Cost			$1,065.00
Quantity (Units)			1
Total Cost			$1,065.00

Narrative The Nitrogen Supply System consists of three nitrogen tanks, pressure gauges, hoses, and a regulator

With exposure to oxygen in the expansion tank at elevated temp, the Dowtherm Q fluid will oxidize. The inert gas blanketing the system on the Thermal Fluid Heater, in conjunction with the Nitrogen Supply System, minimizes oxidation of the thermal fluid.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Oxygen Enrichment System		
Equip ID	O2-1	***System:***	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	Air Products and Chemicals, Inc.		
Contact and Phone No.	Scott B. Sclleicher	864-967-9010	**Fax:** 864-967-7249
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The Oxygen Enrichment System provides additional oxygen to Vortec's CMS™ combustion air.

Actual equipment will be supplied by Air Products and Chemicals, Inc. Air Products and Chemicals, Inc. will charge $0.40/scf of liquid oxygen used.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Holding Tank Transfer Pump
Equip ID	P-1
System:	Receiving
Engineer	Craig Smith, FWEC

Sourse or Seller	Voigt-England Co., Inc.
Contact and Phone No.	Buddy Dufau 205-592-8191 **Fax:** 205-591-6120
Quote Type	Supplier Budgetary
Equip Cost	$15,893.00
Quantity (Units)	1
Total Cost	$15,893.00

Narrative The Holding Tank Transfer Pump is a peristaltic pump used to transfer the stirred slurry from the TTA Slurry Hold-up Tank to the centirfuges.

This pump may be used to provide washdown water for cleanout of the conveyors, screws, etc.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Oxidizing Zone Recycle Pump (Incl w APC-1)
Equip ID	P-10A
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.
Contact and Phone No.	Ron Dawe 519-885-5513 **Fax:** 519-885-6992
Quote Type	Supplier Budgetary
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative A Oxidizing ZoneRecycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Oxidizing Zone Recycle Pump (Incl w APC-1)		
Equip ID	P-10B	***System:***	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A Oxidizing ZoneRecycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Washdown Return Water Pump		
Equip ID	P-11	***System:***	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	Voigt-England Co., Inc.		
Contact and Phone No.	Buddy Dufau	205-592-8191	**Fax:** 205-591-6120
Quote Type	Supplier Budgetary		
Equip Cost			$21,093.00
Quantity (Units)			1
Total Cost			$21,093.00

Narrative The maintenance Washdown Return Pump is identical to the Holding Tank transfer Pump. A peristaltic pump used to return washdown water back to the TTA.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	TTA Transfer Pump
Equip ID	P-2
System:	Receiving
Engineer	Craig Smith, FWEC

Sourse or Seller	Voigt-England Co., Inc.		
Contact and Phone No.	Buddy Dufau	205-592-8191	**Fax:** 205-591-6120
Quote Type	Supplier Budgetary		
Equip Cost			$15,893.00
Quantity (Units)			1
Total Cost			$15,893.00

Narrative The TTA transfer pump is a peristaltic pump used to pump the decanted supernate from the centirfuges back to the TTA.

This pump may be used to provide washdown water for cleanout of the conveyors, screws, etc.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Water Hold-up Tank Pump
Equip ID	P-3
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TBD
Contact and Phone No.	Lee Dilthey (FWENC) 423-481-8647 **Fax:**
Quote Type	Engineering Estimate
Equip Cost	$1,118.00
Quantity (Units)	1
Total Cost	$1,118.00

Narrative The Water Hold-up Tank Pump provides water to the Evaporative Cooler.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	SOx Scrubber Sump Recycle Pump (Incl w APC-1)		
Equip ID	P-4A	**System:**	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A Sox Scrubber Sump Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	SOx Scrubber Sump Recycle Pump (Incl w APC-1)		
Equip ID	P-4B	**System:**	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A Sox Scrubber Sump Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	NOx Conditioner Sump Recycle Pump (Incl w APC-1)
Equip ID	P-5A
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.
Contact and Phone No.	Ron Dawe 519-885-5513 **Fax:** 519-885-6992
Quote Type	Supplier Budgetary
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative A NOx Conditioner Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	NOx Conditioner Sump Recycle Pump (Incl w APC-1)
Equip ID	P-5B
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A NOx Conditioner Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Urea Injection Pumps (Incl w APC-1)
Equip ID	P-6A
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC
Sourse or Seller	TurboSonic Inc.
Contact and Phone No.	Ron Dawe 519-885-5513 **Fax:** 519-885-6992
Quote Type	Supplier Budgetary
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative A Urea Injection Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Urea Injection Pumps (Incl w APC-1)		
Equip ID	P-6B	***System:***	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A Urea Injection Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Caustic Storage Tank Pump (Incl w APC-1)
Equip ID	P-7A
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC
Sourse or Seller	TurboSonic Inc.
Contact and Phone No.	Ron Dawe 519-885-5513 **Fax:** 519-885-6992
Quote Type	Supplier Budgetary
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative A Caustic Storage Tank Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Caustic Storage Tank Pump (Incl w APC-1)		
Equip ID	P-7B	***System:***	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A Caustic Storage Tank Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Cooling Tower Pump		
Equip ID	P-8	**System:**	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	Fergusen Equipment Co.		
Contact and Phone No.	Tom ____	423-524-1491	**Fax:** 423-637-8304
Quote Type	Supplier Budgetary		
Equip Cost			$6,397.00
Quantity (Units)			1
Total Cost			$6,397.00

Narrative The Cooling Tower Pump has a split case. 875 GPM @ 100' TDH, non-overload.

Dimension TBD

Sketch, or Catalog Cut

Weinman 4L2-182

Equip Data Sheet

Equip Name	Drag Conveyor Recycle Pump		
Equip ID	P-9	***System:***	Product Handling System
Engineer	Craig Smith, FWEC		

Sourse or Seller	Voigt-England Co., Inc.		
Contact and Phone No.	Buddy Dufau	205-592-9191	**Fax:** 205-591-6120
Quote Type	Supplier Budgetary		
Equip Cost			$15,893.00
Quantity (Units)			1
Total Cost			$15,893.00

Narrative The recycle pump is a peristaltic pump used to transfer the stirred slutty from the TTA Slurry-Hold-up Tank to the centirfuges. This pump may also be used to provide washdown water for cleadout of conveyors, screws, etc.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Pneumatic Conveying System
Equip ID	PCS-1
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Smoot Co.		
Contact and Phone No.	Jeffery P. Pitts	913-362-1710	**Fax:** 913-362-7863
Quote Type	Supplier Budgetary		
Equip Cost			$46,729.00
Quantity (Units)			1
Total Cost			$46,729.00

Narrative The Pneumatic Conveying System will convey the feed from the Dense Phase Transporter to one of the three Dry Feed Storage Hoppers. Pipe Grooved in the field by General Contractor. Feed Rate 4 ton/hr (80 CF/Hr), Bulk density 90 lb/CF, Feed Size -35 mesh.
Includes: Surge Hopper, High Level Indicators, Air Cylinder Butterfly Valve, Dense Phase Transmitter, 200 LF Product Concey Line, Product Convey Elbows, Grooved Pipe Couplings, and 2 Sl;ide-type Diverter Valves.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Quench Tank / Drag Conveyor		
Equip ID	QT-1	***System:***	Product Handling System
Engineer	Craig Smith, FWEC		

Sourse or Seller	Webb-Materials Handling Equipment		
Contact and Phone No.	Dave Ihrig	770-426-3900	**Fax:** 770-426-3919
Quote Type	Supplier Budgetary		
Equip Cost			$139,781.00
Quantity (Units)			1
Total Cost			$139,781.00

Narrative The Quench Tank with a Drag Conveyor is used to cool the glass and produce frit before the conveyor moves the frit up to drop into the slag bins provided by FDF.

24" W x 2-' L, 5" L horiz water-tight compartment. A 17' long incline at 30 deg slope (Approx 8' discharge height). Opreates at 12 FPM to convey 1.200 lb/hr of glass frit. Two strands of deslagger chain. Overflow weir and Box.

Dimension 24" W x 20" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	SO2 Scrubber (Incl w APC-1)		
Equip ID	S-1	***System:***	Air Pollution Control System
Engineer	Craig Smith, FWEC		

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The SO2 Scrubber Includes internal Recirculation Tank, Flanged inlet and outlet.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name NOx Scrubber (Incl w APC-1)

Equip ID S-2 **System:** Air Pollution Control System

Engineer Craig Smith, FWEC

Sourse or Seller TurboSonic Inc.

Contact and Phone No. Ron Dawe 519-885-5513 **Fax:** 519-885-6992

Quote Type Supplier Budgetary

Equip Cost $0.00

Quantity (Units) 1

Total Cost $0.00

Narrative The Nox Scrubber includes FRP Construction, Flanged at both ends.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Feed Blender		
Equip ID	SB-1	**System:**	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Material Dynamics, Inc.		
Contact and Phone No.	Billey D. Quinton, Jr.	770-429-1550	**Fax:** 770-429-1571
Quote Type	Supplier Budgetary		
Equip Cost			$5,591.00
Quantity (Units)			1
Total Cost			$5,591.00

Narrative The 65 CF Surge Bin is located on thr 4th floor. Structural legs provide 6VF (Vertical Feet) clearance below the discharge flange.

Includes: Mac wWork Bin, 65 CF, 48" Dia x 4' straight wall carbon steel construction, all product contact parts. 60 deg hopper, flanged discharge to mate 12" orifice gate. 12" air operated orifice gate.

Dimension 48" Dia x 4' High

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Loss-in Weight Feeder
Equip ID	SC-1
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Material Dynamics, Inc.
Contact and Phone No.	Billey D. Quinton, Jr. 770-429-1550 **Fax:** 770-429-1571
Quote Type	Supplier Budgetary
Equip Cost	$21,381.00
Quantity (Units)	1
Total Cost	$21,381.00

Narrative The Loss-in-Weight Feeder is used to control the feed rate to the Vortec CRV Reactor in the Vortec Cyclone Melting System (CMS). It provides volumetric metering with gravimetric validation of throughput.

Dry Matl Feeder: 50 CFH, 2.65 CF Tuf-Flex Internal Hopper, 5 CF refill Hopper, Vinyl, Polyethylene and 304 ss construction. Platform Scale: loadcell Capacity (4) 500 lb with summing box, ss and Alum constr.

Dimension TBD

Sketch, or Catalog Cut

Accurate Model 902

Equip Data Sheet

2295

Equip Name	Sump Recirculation Tank (Incl w APC-1)
Equip ID	SMP-1
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A 1,000 gallon FRP recirculation tank with a covered top.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Sump Recirculation Tank (Incl w APC-1)
Equip ID	SMP-2
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.		
Contact and Phone No.	Ron Dawe	519-885-5513	**Fax:** 519-885-6992
Quote Type	Supplier Budgetary		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative A 1,000 gallon FRP recirculation tank with a covered top.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Water Cooled SR System
Equip ID	SR-1
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$430,827.00
Quantity (Units)			1
Total Cost			$430,827.00

Narrative The Seperator Reservoir receives the glass from the CRV and then flows into the Drag Conveyor Quench Tank. Hot gases exit the Seperator Reservoir into the Refractory Lined Duct.

The water cooled component is fabricated from steel.

Dimension TBD

Sketch, or Catalog Cut

See Layout Dwg

Equip Data Sheet

Equip Name	Glass Channel Comb. System Blower (Included with SR-1)
Equip ID	SR-1-2
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Provides combustion air flow to the roof burners. Blower is equiped with a variable speed drive to control the combustion air flow.

Dimension 28.5" x 33.5" x 36"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	Glass Channel Comb. System Burner (Included with SR-1)
Equip ID	SR-1-3
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec
Sourse or Seller	Vortec Corporation
Contact and Phone No.	R.K. Hnat 610-489-2255 **Fax:** 610-489-3185
Quote Type	Supplier Factored PO
Equip Cost	$0.00
Quantity (Units)	6
Total Cost	$0.00

Narrative Gas heated system provides extra heat in the glass channel to ensure that glass will not solidify.

Dimension 52" x 20" x 12"

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	SR Refractory (Fired shapes) (Included with SR-1)
Equip ID	SR-1-4
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation
Contact and Phone No.	R.K. Hnat 610-489-2255 **Fax:** 610-489-3185
Quote Type	Supplier Factored PO
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative Located inside the SR unit. The refractory is used to line and protect the SR steel walls during poecessing.

Cast specifically to fit the SRGC.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet 2295

Equip Name	SR Refractory (Balance) (Included with SR-1)
Equip ID	SR-1-5
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Located inside the SR unit. The refractory is used to line and protect the SR steel walls during poecessing.

Generic Industry Standard Shapes.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	SR Refractory Insulation (Included with SR-1)		
Equip ID	SR-1-6	***System:***	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative Located inside the SR unit. The refractory insulation is used between the steel walls and refractory.

Serves to control thermal heat loss between thre refractory and steel shell. Also acts to control difference in thermal coefficients between refractory and steel wall.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet 2295

Equip Name	Water Sampling System		
Equip ID	SS-1	**System:**	Water Treatment System
Engineer	Craig Smith, FWEC		

Sourse or Seller	Bristol Equipment Company		
Contact and Phone No.	C.F. Phalen	630-553-7161	**Fax:** 630-553-5981
Quote Type	Supplier Budgetary		
Equip Cost			$8,598.00
Quantity (Units)			1
Total Cost			$8,598.00

Narrative The Water Sampling System samples the output of the Water treatment Package for later Laboratory Analysis.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name	Glass Product Sampling System
Equip ID	SS-2 — ***System:*** Product Handling System
Engineer	Craig Smith, FWEC

Sourse or Seller	Bristol Equipment Company
Contact and Phone No.	C.F. Phalen 630-553-7161 **Fax:** 630-553-5981
Quote Type	Supplier Budgetary
Equip Cost	$6,467.00
Quantity (Units)	1
Total Cost	$6,467.00

Narrative The Glass Product Sampling System samples the 1/16" Fritter Glass Beads output in a vertical drop chute from the Drag Flite Conveyor. Samples to be analyzed in a Laboratory.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	TTA Slurry Hold-up Tank		
Equip ID	TK-1	***System:***	Receiving
Engineer	Craig Smith, FWEC		

Sourse or Seller	Rodgers-Turner & Associates, Inc.		
Contact and Phone No.	Leonard M. Barger	423-894-2958	**Fax:** 423-899-6847
Quote Type	Supplier Budgetary		
Equip Cost			$14,204.00
Quantity (Units)			1
Total Cost			$14,204.00

Narrative The Slurry Hold-up Tank is an above the ground 8,000 gallon, filament wound reinforced thermoset plastic vessel mfg per ASTM D-3299-95a. It has an inner corrosion liner fab from Isophthalic Polyester Resin. Flat bottom with a dish head.

Includes an agitator mounting Flange.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Mixer for TTA Slurry Hold-up Tank
Equip ID	TK-1-1
System:	Receiving
Engineer	Craig Smith, FWEC

Sourse or Seller	Rodgers-Turner & Associates, Inc.		
Contact and Phone No.	Leonard M. Barger	423-894-2958	**Fax:** 423-899-6847
Quote Type	Supplier Budgetary		
Equip Cost			$8,422.00
Quantity (Units)			1
Total Cost			$8,422.00

Narrative The integral mixer is a heavy duty Top Entering Agitator with a 8" - 150# ASA steel mounting flange. All wetted parts are carbon steel. It has a 142" x 2" Dia shaft with dual 44" Dia turbines.

Shaft and turbine assy will be driven through a speed reducer with in-line helical gearing and a single gear reduction at an output speed of 45 RPM. It includes motor coupling and coupling guard.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Condensate Hold-up Tank
Equip ID	TK-2
System:	Feed Prep
Engineer	Craig Smith, FWEC
Sourse or Seller	TBD
Contact and Phone No.	Lee Dilthey (FWENC) 519-885-5513
Fax:	
Quote Type	Engineering Estimate
Equip Cost	$22,365.00
Quantity (Units)	1
Total Cost	$22,365.00

Narrative There is one 30,000 gallon Dryer Screw Heat Exchanger Condensate Tank.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Radon Degasification Tank
Equip ID	TK-3
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TBD		
Contact and Phone No.	Lee Dilthey (FWENC)	423-481-8647	**Fax:**
Quote Type	Engineering Estimate		
Equip Cost			$5,591.00
Quantity (Units)			1
Total Cost			$5,591.00

Narrative A 1,000 gallon polyethylene Radon Degasification Tank.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Urea Storage Tank (Incl w APC-1)
Equip ID	TK-4
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.
Contact and Phone No.	Ron Dawe 519-885-5513 **Fax:** 519-885-6992
Quote Type	Supplier Budgetary
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative A 1,000 gallon polyethylene tank with a covered top and a agitator.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Caustic Storage Tank (Incl w APC-1)
Equip ID	TK-5
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	TurboSonic Inc.
Contact and Phone No.	Ron Dawe 519-885-5513 **Fax:** 519-885-6992
Quote Type	Supplier Budgetary
Equip Cost	$0.00
Quantity (Units)	1
Total Cost	$0.00

Narrative A 1,000 gallon polyethylene tank with a covered top and a agitator.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Washdown Water Return Tank		
Equip ID	TK-6	*System:*	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	Rodgers-Turner & Associates		
Contact and Phone No.	Leonard M. Barger	423-894-2958	**Fax:** 423-899-6874
Quote Type	Supplier Budgetary		
Equip Cost			$22,689.00
Quantity (Units)			1
Total Cost			$22,689.00

Narrative The 8,000 gallon FRP Washdown Water Return Tank with integral in-tank mixer is identical to the transfer Tank Area (TTA) Slurry Hold-up Tank with integral in-tank mixer.

The tank is an above ground 8,000 gal. Filament wound reinforced thermoset plastic vessel mfg. Per ASTM D-3299-95a. It has an inner corrosion liner fab w Osophthalic Polyester Resin. Flat bottomed with a dish head. Includes integral mixer.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Dry Feed Transporter		
Equip ID	TSC-1	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc		
Contact and Phone No.	Keith Holt	800-725-7272	**Fax:** 817-926-4113
Quote Type	Supplier Budgetary		
Equip Cost			$14,212.00
Quantity (Units)			1
Total Cost			$14,212.00

Narrative Transports the Dry Feed from metering screws MS-1, MS-2, and MS-3 to the Blender.

Approx 4" x 1.5" x 29'-3" Long, carbon steel tubular feeder with a 1 HP drive at 16 RPM with a varispeed controller.

Dimension Approx 4" x 1.5" x 29'-3" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Dry Feed Transporter
Equip ID	TSC-2
System:	Feed Blending & Storage
Engineer	Craig Smith, FWEC

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc		
Contact and Phone No.	Keith Holt	800-725-7272	**Fax:** 817-926-4113
Quote Type	Supplier Budgetary		
Equip Cost			$28,826.00
Quantity (Units)			1
Total Cost			$28,826.00

Narrative Transports the Dry Feed from metering screws MS-4, MS-5, and MS-6 to TSC-3.

Approx 4" x 1.5" x 31'-9" Long, 316 stainless steel tubular feeder with a 1 HP drive at 16 RPM with a varispeed controller.

Dimension Approx 4" x 1.5" x 31'-9" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Dry Feed Transporter		
Equip ID	TSC-3	***System:***	Feed Blending & Storage
Engineer	Craig Smith, FWEC		

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc		
Contact and Phone No.	Keith Holt	800-725-7272	**Fax:** 817-926-4113
Quote Type	Supplier Budgetary		
Equip Cost			$17,785.00
Quantity (Units)			1
Total Cost			$17,785.00

Narrative Transports the Dry Feed from TSC-3 to the blender.

Approx 4" x 1.5" x 7'-0" Long, 316 stainless steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Dimension Approx 4" x 1.5" x 7'-0" Long

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

2295

Equip Name	Baghouse Transfer Screw
Equip ID	TSC-4
System:	Air Pollution Control System
Engineer	Craig Smith, FWEC

Sourse or Seller	Hayes & Stolz Industrial Mfg. Co., Inc.		
Contact and Phone No.	Keith Holt	800-725-7272	**Fax:** 817-926-4133
Quote Type	Supplier Budgetary		
Equip Cost			$61,504.00
Quantity (Units)			1
Total Cost			$61,504.00

Narrative Transports the Bag-house solids to the CMS™ recycle input hopper (Hopper supplied by Vortec). It is a 4" x 1.5" x ___ L ss tublar screw frder with a 1 HP drive at ___ RPM with varispeed controller.

The transfer screw moves material from near ground level outside the building into the building and up to the third floor. Material has to be moved approximately 35 LF horizontally.

Dimension 4" x 1.5 " x ___ L

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	HEPA Filter Vacuum		
Equip ID	VAC-1	***System:***	BOP, Other Process Equip
Engineer	Craig Smith, FWEC		

Sourse or Seller	Vector Technologies, LTD.		
Contact and Phone No.	Bret Alexander	414-247-7411	**Fax:** 414-247-7110
Quote Type	Supplier Budgetary		
Equip Cost			$55,521.00
Quantity (Units)			1
Total Cost			$55,521.00

Narrative The mobile HEPA filtered vacuum is for evacuating dry feed components. The vacuum is transportable to location needed.

150 lf 4" hose, drum filter/ stand assy, drum loader, wheel mounted, integrated 2 CY Hopper.

Dimension TBD

Sketch, or Catalog Cut

Vector Spartan II

Equip Data Sheet

E 2295

Equip Name	Air Heater System		
Equip ID	VAH-1	*System:*	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$431,913.00
Quantity (Units)			1
Total Cost			$431,913.00

Narrative This system consists of a Air Heater from Stetler & Brinck, Inc. that provides heated air to the CRV reactor, a Refractory Lined Duct from the SR/GC, and a Refractory Lined transfer Duct to the Evaporative Cooler, EC-1.

The Air Heater Assembly consists of a 10 guage steel shell with Control Panel. NEMA 12 enclosure.

Dimension TBD

Sketch, or Catalog Cut

Not Available

Equip Data Sheet

Equip Name	Indirect Fired Air Heater (Included with VAH-1)
Equip ID	VAH-1-1
System:	Vortec Vitrification System
Engineer	J. Santioanni, Vortec

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The Air Heater Assembly consists of a 10 ga steel Shell insulated with rigidized fiber blanket refractory. The combustion system is complete with NEPA valve train, electric spark ignition, and high/low control Load control panel NEMA 12 enclosure..
The gas valve train features main gas shutoff valves, ball valve manual gas cocks, gas pressure regulators, vent and pilot selenoids, and high and low pressure switches Prepiped and prewired and complete with a control panel.

Dimension 6' W x 10' H x 7.5' D

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	Refractory Lined SR/GC Duct (Included with VAH-1)		
Equip ID	VAH-1-2	**System:**	Vortec Vitrification System
Engineer	J. Santioanni, Vortec		

Sourse or Seller	Vortec Corporation		
Contact and Phone No.	R.K. Hnat	610-489-2255	**Fax:** 610-489-3185
Quote Type	Supplier Factored PO		
Equip Cost			$0.00
Quantity (Units)			1
Total Cost			$0.00

Narrative The Refractory Lined Duct is between thr SR/GC and the Epaorative Cooler. The duct system includes the transition segment that attaches to the Evaporative Cooler.

The refractory inner lining provides thermal protection to the steel walls.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

Equip Name Structural Steel, CMS™ Tower

Equip ID VST-1 ***System:*** Vortec Vitrification System

Engineer Craig Smith, FWEC

Sourse or Seller TBD

Contact and Phone No. R. K. Hnat 610-489-2255 **Fax:** 610-489-3185

Quote Type Factored PO

Equip Cost $394,449.00

Quantity (Units) 1

Total Cost $394,449.00

Narrative A self contained structural tower that is used to support the Vortec CMS™ System. It also will provide support for the Batch Feed System.

Dimension TBD

Sketch, or Catalog Cut

Not Applicable

Equip Data Sheet

2295

Equip Name	Water Treatment Package
Equip ID	WT-1
System:	Water Treatment System
Engineer	Craig Smith, FWEC

Sourse or Seller	L.C. Hammock Co.m Inc.		
Contact and Phone No.	Dave Turner	423-671-0950	**Fax:** 423-671-0950
Quote Type	Supplier Budgetary		
Equip Cost			$50,321.00
Quantity (Units)			1
Total Cost			$50,321.00

Narrative The Waste Water treatment System is an Alert 2000 Packaged Compact Treatment System. It is skid mounted with carbon steel construction.

Includes: Model 100-WT capable of processing 20 GPM. Filterpress, seld-containedautomated chemical conditioning and suspended solids separation system, lift station, chemical neutalization, flocculation, liquid solid separation and dewatering.

Dimension TBD

Sketch, or Catalog Cut

Hoffland Environmental Inc., Model Alert 2000

DATA SHEET NO. 2007-M-DS-001	REV. 0	ISSUE DATE 4/23/99
PAGE 1 of 2	REQUISITION NO.	

DATA SHEET

	PROCURED BY FWENC	INSTALLED BY Subcontractor
PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT	EQUIPMENT NO.
Centrifuge	CEN-1, CEN-2

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of two (2) centrifuges.

The centrifuges shall conform to appropriate and applicable standards.

The centrifuges will be used to separate suspended solids and water from a radioactive slurry consisting of mine ore tailings and stabilizing grout.

PERFORMANCE REQUIREMENTS

Design throughput	60 gpm
Slurry liquid	Water
Slurry solids	Uranium mine ore tailings & stabilizing grout
Inlet consistency	10% to 30% total solids by weight
Solids loading	4,000 to 10,000 lb/hr total solids (per unit)
Solids capture	80% or more without polymer
Cake dryness	50% total solids

DESIGN REQUIREMENTS

316L solid bowl decanter
316L wetted parts
High performance scroll
Automatic clean in place
Auto start-up/shut-down sequencing
Ceramic feed and discharge ports
Automatic torque control
Adjustable weirs for control of effluent pool depth
PLC control system and electrical control panel with touch screen operator interface

The following manufacturer's data to be provided as indicated.	NUMBER OF COPIES			Type of Data (continued)	NUMBER OF COPIES		
	W'Bids	Approval	Certified		W'Bids	Approval	Certified
1. Outline Dimensional Drawings	✓		✓	6. Manuf. Standard Test & Inspection Reports			✓
2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

PREPARED BY	REVIEWED	APPROVED BY

2295

DATA SHEET NO. 2007-M-DS-001	REV. 0	ISSUE DATE 4/23/99
PAGE 2 of 2	REQUISITION NO.	
PROCURED BY FWENC	INSTALLED BY Subcontractor	

DATA SHEET

PROJECT TITLE	CLIENT	
Fluor Daniel Fernald Silos 1 & 2 Remediation	Vortec Corporation	
JOB TITLE	**BUILDING**	**PLANT**
Vortec Cyclone Melting System Commercial Plant		

EQUIPMENT	EQUIPMENT NO.
Centrifuge	CEN-1, CEN-2

ELECTRICAL REQUIREMENTS

Main Drive

Motor nameplate horsepower rating shall be equal to, or greater than, the maximum brake horsepower of the drive system at its maximum hydraulic flow rate.

Motor 460/3/60
TEFC
Continuos duty
Class F insulation limited to level B temperature rise
1.15 service factor
Motor shall be specifically designed for VFD duty
Motor shall be capable of restart within 1 hour after any shutdown
Motor shall not take longer than 5 minutes to accelerate to full rated revolutions at 90% of nameplate voltage
Bearings shall have a B-10 life rating of 40,000 hours

Secondary Drive

Secondary drive system shall allow for the differential speed control between the centrifuge bowl and conveyor

Motor 460/3/60
TEFC
Continuos duty
Class F insulation limited to level B temperature rise
1.15 service factor
Motor shall be specifically designed for VFD duty

Suggested Model: Andritz Model D5LL

The following manufacturer's data to be provided as indicated.	NUMBER OF COPIES W'Bids	Approval	Certified	Type of Data (continued)	NUMBER OF COPIES W'Bids	Approval	Certified
1. Outline Dimensional Drawings	✓		✓	6. Manuf. Standard Test & Inspection Reports			✓
2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

PREPARED BY	REVIEWED	APPROVED BY

DATA SHEET

DATA SHEET NO. 2007-M-DS-002	REV. 0	ISSUE DATE 4/23/99	
PAGE 1 of 1	REQUISITION NO.		
PROCURED BY FWENC	INSTALLED BY Subcontractor		
PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT. Vortec Corporation		
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT	
EQUIPMENT Thermal Drying Screw		EQUIPMENT NO. DS-1, DS-2	

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of two (2) thermal screw conveyor dryers (hot oil screws).

The dryer screws shall conform to appropriate and applicable standards.

The dryer screws will be used to dry a dewatered slurry from 50% H_2O to 5% H_2O.

Screw conveyor dryers to consist of multi-screw unit(s) with fully enclosed vapor hood. Screws to be of hollow construction with pressure boundary pathway for thermal fluid in screw flights and return path in central bore. The multiple screws are to be driven by a common electric motor and associated gear reducer assembly.

Parameters associated with the dewatered slurry material and the associated transfer rates are listed following:

Nominal rate of transfer	8 TPH wet basis
Nominal density of solids	90 lb/ft^3
Percent solids of dewatered slurry	50%
Density of dewatered slurry	10.2 lb/gal (76.2 lb/ft^3)
Slurry liquid	Water
Material of construction	Carbon steel

REQUIRED OPTIONS/FEATURES
Direct coupled, variable frequency drive
Flex hoses and associated fittings
Shaft seals
Enhanced bearing design for all shaft load points

Suggested vendor/model: Svedala Holo-Flite Dryer, Model Q2420-6

The following manufacturer's data to be provided as indicated.	NUMBER OF COPIES W'Bids	Approval	Certified	Type of Data (continued)	NUMBER OF COPIES W'Bids	Approval	Certified
1. Outline Dimensional Drawings	✓		✓	6. Manuf. Standard Test & Inspection Reports			✓
2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

PREPARED BY	REVIEWED	APPROVED BY

	DATA SHEET NO. 2007-M-DS-003	REV. 0 2295	ISSUE DATE 4/23/99
	PAGE 1 of 1	REQUISITION NO.	
# DATA SHEET	PROCURED BY FWENC	INSTALLED BY Subcontractor	
PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation		
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT	

EQUIPMENT Thermal Fluid Heater	EQUIPMENT NO. HTR-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) thermal fluid heater.

The thermal fluid heater shall conform to appropriate and applicable standards.

The thermal fluid heater is to provide the heating medium for a drying process.

The heater system shall comprise all tanks, pumps, blowers, instruments, operating panel(s), etc. required for unit operation. The system shall be designed so as to minimize interface requirements.

The heater will conform to the following requirements;

Heating requirement	12 MM Btu/hr
Primary fuel	Natural gas
Circulation rate	850 gpm
Supply temperature	600 °F
Thermal fluid	Dowtherm Q
Electrical service	480/3/60

REQUIRED OPTIONS/FEATURES

Thermal fluid pump
Fill and drain pump
1000 gal expansion tank with tank tower
2000 gal drain tank
Exhaust stack
Steam condenser

Suggested vendor/model: GTS Energy, Model DH-V-30/40

The following manufacturer's data to be provided as indicated.	NUMBER OF COPIES			Type of Data (continued)	NUMBER OF COPIES		
	W'Bids	Approval	Certified		W'Bids	Approval	Certified
1. Outline Dimensional Drawings	✓		✓	6. Manuf. Standard Test & Inspection Reports			✓
2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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PROJECT TITLE	CLIENT	
Fluor Daniel Fernald Silos 1 & 2 Remediation	Vortec Corporation	
JOB TITLE	**BUILDING**	**PLANT**
Vortec Cyclone Melting System Commercial Plant		

EQUIPMENT	EQUIPMENT NO.
Hammer Mill	BM-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) hammermill/shredder.

The mill will be used to size reduce any agglomerated material exiting the thermal dryer screws. The mill shall reduce the agglomerated material to a maximum of 35 mesh under.

The particle size of the non-agglomerated material is less than 35 mesh under, therefore the function of the mill is strictly de-lumping, not particle size reduction.

Material density 90 lb/ft^3
Feed rate 5 TPH

Unit to be of basic carbon steel construction with removable cover for access to housing.
Rotor to be equipped with removable hammers
Housing to be sealed at all penetrations and have provision for venting
Screen to be easily removable with 1/32" perforation

Motor 480/3/60
TEFC
Continuos duty
Class F insulation limited to level B temperature rise
1.15 service factor

Suggested vendor/model: Scott "Shredder-izer" Model SH 18" x 18"

The following manufacturer's data to be provided as indicated.	NUMBER OF COPIES W'Bids	Approval	Certified	Type of Data (continued)	NUMBER OF COPIES W'Bids	Approval	Certified
1. Outline Dimensional Drawings	✓		✓	6. Manuf. Standard Test & Inspection Reports			✓
2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT Dense Phase Pneumatic Conveying System	EQUIPMENT NO. PCS-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) dense phase pneumatic conveying system.

The dense phase pneumatic conveying system will convey the material from the output of the hammermill approximately 80 vertical feet and distribute it among three dry feed storage hoppers which are arranged adjacent to each other in a horizontal, in line arrangement.

Material density	90 lb/ft^3
Material size	Max 35 mesh
Feed rate	4 TPH
Conveying distance	Approximately 80 vertical feet and 20 horizontal feet.
No. of pickup points	1 from Hammermill
No. of destination points	3 at dry storage bins

System shall consist of:

- Surge hopper with approximately 8.5 ft^3 of storage. Bin to be a 60° angle hopper supported by three legs with level indicator openings and air jet openings in cone. Hopper to incorporate high level indicator.
- Dense phase transmitter with 10ft^3 total capacity and 8.5 ft^3 batch size. Transmitter to be equipped with air operated inlet valve, additional flanged opening in head for access, air bypass valve with control pressure regulator and solenoid, air inlet pressure regulator, air flow meter, fixed flow control orifice, manual emergency shutoff ball valve, relief valve per ASME code, high level indicator, pressure supply gauge, bypass pressure gauge, and gauge manifold and support rack.

System to be supplied with all related control devices, and ancillary equipment.

Air supply to be provided by others.

Carbon steel acceptable material of construction for all vessel and primary components.

Suggested vendors: Smoot Company
Dynamic Air Conveying Systems

The following manufacturer's data to be provided as indicated.	NUMBER OF COPIES			Type of Data (continued)	NUMBER OF COPIES		
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1. Outline Dimensional Drawings	✓		✓	6. Manuf. Standard Test & Inspection Reports			✓
2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT L-valve/Transfer Screw with Loss-in-weight Feeder	EQUIPMENT NO. SC-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) loss-in-weight feeder.

The loss-in-weight feeder shall accept material from an intermediate surge bin (SB-1) and shall incorporate an internal hopper. The material shall be conveyed from the unit in a horizontal configuration by means of a rotary screw. The feeder shall incorporate an integral platform scale. The unit shall feed material with an accuracy of .75% minimum.

Material density	90 lb/ft^3
Material state	Dry, powdery
Feed rate	2,000 PPH

System to be supplied with all related control devices and ancillary equipment with all appropriate and required safety devices.

Material of construction:	Stainless steel as primary material to combat corrosive action of dry feed
Drive Motor	180 VDC TEFC Class F insulation limited to level B temperature rise
Suggested vendors and models:	AccuRate Model 920 with Model 9001 Platform Scale

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2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT Feed Blender	EQUIPMENT NO. FB-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) dry feed blender.

The blender shall accept dry material input from two sources and blend those materials such that the resulting mixture is essentially homogenous. Blending action to be by mechanical agitation, unit is not to be an air jet blender. Blender to output mixed material via air operated slide gate.

Material density	90 lb/ft^3
Material state	Dry, powdery
Batch size	65 ft^3

System to be supplied with all related control devices and ancillary equipment with all appropriate and required safety devices.

Material of construction: Stainless steel

Motor
480/3/60
TEFC
Continuous duty
Class F insulation limited to level B temperature rise
1.15 service factor

Suggested vendors and models: Hayes & Stolz Model No. HR86 SSC Mixer
Dynamic Air Conveying Systems Model No. F-1500

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2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT Air Pollution Control System	EQUIPMENT NO. APC-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) Air Pollution Control system.

The Air pollution control system shall conform to appropriate and applicable standards.

The air pollution control system will be used to for pretreatment of an air effluent for the removal of particulates, NO_X, and SO_X.

SCRUBBER PERFORMANCE REQUIREMENTS

Inlet Gas Conditions	To Evaporative Cooler	To Scrubber
Gas Volume (ACFM)	3591	2110
Gas Temperature (°F)	2400	450
Gas Humidity (% v/v)	27.0	53.54
SO_2 Loading (lb/hr)	28.2	28.2
NO_X Loading (lb/hr)	1.83	1.83

Outlet Gas Conditions	
Gas Volume (ACFM)	553
Gas Temperature (°F)	100
Gas Humidity (% v/v)	Saturated
SO_2 Loading (lb/hr)	< 0.10
NO_X Loading (lb/hr)	< 0.07

Operating Parameters	
Total Pressure Drop Across Scrubber (" H_2O)	3.0
Evaporative Cooler:	
– Fresh Water Flow Rate (gpm)	3.0
– Compressed Air Consumption (SCFM)	30 to 40
Quench Stage:	
– Fresh Water Flow Rate (gpm)	3.0
– Compressed Air Consumption (SCFM)	15.0
SO_2 Removal/Cooling Stage:	
– Scrubbing Medium (recirculated)	NaOH/Water
– Scrubbing/cooling Liquid Flow Rate (gpm)	100
– NaOH Makeup Rate (gpm)	0.22 @ 20% wt.
– Blowdown Rate (gpm)	1.67

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4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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JOB TITLE	**BUILDING**	**PLANT**
Vortec Cyclone Melting System Commercial Plant		

EQUIPMENT	EQUIPMENT NO.
Air Pollution Control System	APC-1

Operating Parameters cont.

Oxidation/Reducing Stage

- Medium (Recirculated) NaOCl
- Liquid Flow Rate (gpm) 3.0
- Compressed Air Consumption (SCFM) 13.0
- Blowdwn Rate (gpm) < 0.30

NO_x Neutralization Stage

- Medium (Recirculated) NaOH
- Liquid Flow Rate (gpm) 3.0
- Compressed Air Consumption (SCFM) 13.0
- Blowdwn Rate (gpm) < 0.30

Evaporative Cooler

Cooling Requirements 2400 °F to 450°F
Material of Construction 316L Stainless Steel
Capacity Requirements 3591 ACFM

REQUIRED OPTIONS/FEATURES

Evaporative Cooler

- Flanged inlet and outlet
- Conical bottom with drain connection
- Atomizing nozzles
- Automatic temperature controls
  - 5 gpm maximum water flow
  - 50 SCFM maximum air flow
  - prepiped and mounted with required valves
- Automatic liquid flow control
- Compressed air flow control
  - Air flow indication with 4-20 mA remote signal
  - Local pressure indication and pressure transmitter (4-20 mA)
  - Pressure regulator and relief valves
- Quick connects and flex hose connections
- Pressure indication and isolation shut-off adjusting hand valves for each nozzle air/water connection

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JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT	
EQUIPMENT Air Pollution Control System		EQUIPMENT NO. APC-1	

Inlet/Quench/Cooling Stage

- AL6XN or equivalent construction
- Flanged inlet and outlet

SO_2 Removal Stage

- AL6XN or equivalent construction
- Integral recirculation tank
- Flanged for connection to inlet duct and oxidation stage
- Hydraulic cooling headers with nozzles

Oxidation/Reducing Stage

- FRP Construction
- Flanged at both ends
- Interstage mist elimination stage

NO_X Neutralization Stage

- FRP construction
- Flanged at both ends
- Interstage mist elimination stage

Air Atomizing Nozzles

- AL6XN or equivalent construction
- Internal piping

Entrainment Separator Housing

- Materials of construction
  - Housing FRP
  - Internal media HTPP
  - Spray nozzles CPVC
  - Spray piping CPVC
- Internal banks of entertainment separation media
- Spray bars with hydraulic spray nozzles
- Bolted access hatch
- Bottom drain connections

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3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				
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PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT Air Pollution Control System	EQUIPMENT NO. APC-1

Scrubber Control System

- Variable area flowmeters for flow indication to each nozzle
- Compressed air regulators with gauges for air pressure control
- Individual manual shutoff valves for liquid and air to each nozzle and entrainment separator
- Individual manual throttling valves for liquid control
- Stainless steel piping for air and liquid lines

ANCILLIARY EQUIPMENT

Caustic/Hypo Dosing Pumps

- Quantity – four (4) (2 on-line, 2 redundant)
- Electronic metering pump
- Solenoid driven 120/1/60
- Material of construction – PVC head, TFE diaphram
- Microprocessor based pH controller
- pH sensor to tank insertion

Caustic/Hypo Storage Tanks

- Quantity – two (2)
- Material of construction – one piece polyethylene
- Covered top
- With connections
- Capacity – 1000 gallon

Agitators – For Chemical Mixing

- Quantity – two (2)
- Tank mounted
- Motor 120/1/60

Recirculation Tanks

- Quantity – two (2)
- Material of construction – FRP
- Capacity – 1000 gal
- Covered top
- W/ all required connections

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3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT	EQUIPMENT NO.
Air Pollution Control System	APC-1

ANCILLIARY EQUIPMENT CONT.

Recirculation Pumps

- Quantity – six (6) (3 on-line, 3 redundant)
- Single stage centrifugal
- Material of construction – FRP casing, impeller
- Mechanical seal
- Close coupled motor
- Motor
  - 3600 rpm
  - 240/3/60

Exhaust Fan

- Quantity one (1)
- Centrifugal fan, single inlet, single width
- Backward inclined type wheel
- Material of construction
  - FRP housing
  - FRP wheel
  - FRP encapsulated shaft
  - Teflon/neoprene seal
- Nexus veil chemical barrier
- V-belt drive, OSHA shaft and belt guard
- Motor
  - 1800 rpm
  - 240/3/60

Suggested Vendor: TurboSonic

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3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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Fluor Daniel Fernald Silos 1 & 2 Remediation	Vortec Corporation	
JOB TITLE	**BUILDING**	**PLANT**
Vortec Cyclone Melting System Commercial Plant		

EQUIPMENT	EQUIPMENT NO.
Glass Product Handling System	QT-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) wet ash conveyor with integral quench bath.

The wet ash conveyor will accept the hot glass product output, quench cool it, and convey it out of the water bath into a product output bin.

Configuration - 2' wide x 20' long with 30° inclined section with discharge flange at 10'above grade
Capacity - 1200 lb/hr glass material
Material density - 120 lb/ft^3

Drag conveyor to be top carry double strand scraper type with matched strands of deslagger chain.
Unit to feature integral, horizontal water-tight compartment. Quench bath to be fully enclosed with provision for venting off-gas. Enclosure to be equipped with access portals with abrasion resistant bottom liner, carry and return chain rails with abrasion resistant wear bars and return pan.

Motor 480/3/60
TEFC
Continuos duty
Class F insulation limited to level B temperature rise
1.15 service factor

System to be supplied with all related control devices and ancillary equipment with all appropriate and required safety devices.
Unit to feature:

- submerged bearings with Stellite bushings
- overflow weir and box
- drains with gate valves
- adjustable screw takeup
- structural bracing for inclined section
- electric control panel with Jog Fwd/Rev/Jam/O.L functions
- discharge hood with inspection ports
- painted assembly
- safety pull switch

Suggested vendor: Webb-Materials Handling Co.

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3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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CLIENT	Vortec Corporation
JOB TITLE	Vortec Cyclone Melting System Commercial Plant
BUILDING	
PLANT	
EQUIPMENT	Water Treatment System
EQUIPMENT NO.	WT-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) water treatment system to treat scrubber purge.

The water treatment system shall be a self-contained, automated, chemical conditioning and suspended solids separation system designed to precipitate metals from wastewater. The system shall be capable of removing one or more metals from the wastewater solution to one parts per million (1 ppm). System to be a fully integral, skid mounted package complete with:
Lift station
Chemical neutralization
Flocculation
Liquid solid separation chamber
Motorized rake bottom clarifier
Filter press

Input flow rate: 3.8 gpm
Material to be removed: Lead to one parts per million (1 ppm)
The following radionuclides to be removed to a level defined by a future interface document:
Lead-210
Radium-226
Thorium-232
Uranium-238

System to be supplied with all related control devices and ancillary equipment with all appropriate and required safety devices.

Suggested vendor and model: Hoffland Environmental Inc. Model Alert 2000

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3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT Vacuum System	EQUIPMENT NO. VAC-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) vacuum loader with HEPA filtration system.

The vacuum shall conform to appropriate and applicable standards.

The vacuum system will be used for cleanup of dry materials from spills and prior to equipment maintenance.

PERFORMANCE REQUIRMENTS

Maximum Capacity	1340 cfm/ 15" Hg
Motor Horse power	50
Power	Electric
Electrical Service	480/3/60
Hose Diameter	4"
Maximum Conveying Distance	500'
Maximum Performance – Bulk	6 tons/hr.

REQUIRED OPTIONS/FEATURES

Primary and Secondary Filtration
HEPA filtration system
Mobile

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3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT
EQUIPMENT Air Compressor System		EQUIPMENT NO. AC-1

This data sheet covers the design, fabrication, testing, inspection, acceptance, and delivery of one (1) air compressor system.

The air compressor shall conform to appropriate and applicable standards.

The air compressor will be used to provide air for the dense phase pneumatic conveying system, product sampling systems, bag filter, radon de-gasification sparging, and miscellaneous air users.

AIR COMPRESSOR

Capacity	360 cfm
Motor Horsepower	75
Motor Type	Rotary Screw
Motor Characteristics	460 V, 3 Phase, 60 HZ, 1800 RPM
Motor Service Factor	1.15
Speed Gearing Requirements	None
Inlet Valve Type	Modulating, vertical
Cooling Method	Air Cooled
Air Filter Requirements	Heavy duty
Air Filter Type	5-Micron canister
Controller Type	Microprocessor based, fully programmable with touch pad

System shall include mounted and wired full voltage motor controllers with 120 V, 60 HZ 1 phase control power.

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3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

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DATA SHEET

DATA SHEET NO. 2007-M-DS-012	REV. 0	ISSUE DATE 4/23/99	
PAGE 2 of 2	REQUISITION NO. 2295		
PROCURED BY FWENC	INSTALLED BY Subcontractor		

PROJECT TITLE Fluor Daniel Fernald Silos 1 & 2 Remediation	CLIENT Vortec Corporation	
JOB TITLE Vortec Cyclone Melting System Commercial Plant	BUILDING	PLANT

EQUIPMENT Air Compressor System	EQUIPMENT NO. AC-1

AIR DRYER

Electrical Requirements	120 V, single phase, 60 HZ, NEMA 4 Enclosure
Controller Type	Solid State PLC
Required Alarms	Failure to switch LED
Design Pressure	150 psig
Design Temperature	-20°F to 300°F
Prefilter and Afterfilter	Required
Purge Air Flow	Based on 67 cfm compressed air at 100 psig, 100°F and 100% RH
Inlet and outlet flanges	1½"

AIR RECEIVER

Capacity	240-gallon
Working Pressure	200 lbs
Configuration	Vertical
Pressure gauge range	0-200 psig
Mechanical Drain Valve	Required

REQUIRED OPTIONS/FEATURES

ASME Code Stamps
ASME coded air/oil reservoir
Direct drive, non-geared
Galvanized steel lube system
Automatic blowdown valve with muffler
Pressure relief valve and discharge check valve
Thermostatic oil mixing valve
Moisture separator and trap
Thermally controlled fan motor
Power interruption relay

Suggested Vendor: Gardner Denver, Ingersal Rand, or Equivalent

The following manufacturer's data to be provided as indicated.	NUMBER OF COPIES			Type of Data (continued)	NUMBER OF COPIES		
	W'Bids	Approval	Certified		W'Bids	Approval	Certified
1. Outline Dimensional Drawings	✓		✓	6. Manuf. Standard Test & Inspection Reports			✓
2. Operation & Performance Data	✓		✓	7. Material Certs. (CMTRs)			✓
3. Literature & Parts List			✓	8. Certificate of Compliance			✓
4. Operating & Maintenance Instrs.			✓				
5. Installation Instructions			✓				

PREPARED BY	REVIEWED	APPROVED BY

Sys No.: 1 **System :** Receiving

Item No. 1 | **Equip ID** P-1 | **Qty** 1 | **Description** Holding Tank Transfer Pump

Motor HP	Elec Load	Weight (lb)	Engineer
15	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Voigt-England Co., Inc.	Buddy Dufau	205-592-8191	205-591-6120

The Holding Tank Transfer Pump is a peristaltic pump used to transfer the stirred slurry from the TTA Slurry Hold-up Tank to the centirfuges.

This pump may be used to provide washdown water for cleanout of the conveyors, screws, etc.

Item No. 2 | **Equip ID** P-2 | **Qty** 1 | **Description** TTA Transfer Pump

Motor HP	Elec Load	Weight (lb)	Engineer
15	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Voigt-England Co., Inc.	Buddy Dufau	205-592-8191	205-591-6120

The TTA transfer pump is a peristaltic pump used to pump the decanted supernate from the centirfuges back to the TTA.

This pump may be used to provide washdown water for cleanout of the conveyors, screws, etc.

Item No. 3 | **Equip ID** TK-1 | **Qty** 1 | **Description** TTA Slurry Hold-up Tank

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Rodgers-Turner & Associates, Inc.	Leonard M. Barger	423-894-2958	423-899-6847

The Slurry Hold-up Tank is an above the ground 8,000 gallon, filament wound reinforced thermoset plastic vessel mfg per ASTM D-3299-95a. It has an inner corrosion liner fab from Isophthalic Polyester Resin. Flat bottom with a dish head.

Includes an agitator mounting Flange.

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Item No.	Equip ID	Qty	Description
4	TK-1-1	1	Mixer for TTA Slurry Hold-up Tank

Motor HP	Elec Load	Weight (lb)	Engineer
1.5	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension: TBD
Throughput: With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Rodgers-Turner & Associates, Inc.	Leonard M. Barger	423-894-2958	423-899-6847

The integral mixer is a heavy duty Top Entering Agitator with a 8" - 150# ASA steel mounting flange. All wetted parts are carbon steel. It has a 142" x 2" Dia shaft with dual 44" Dia turbines.

Shaft and turbine assy will be driven through a speed reducer with in-line helical gearing and a single gear reduction at an output speed of 45 RPM. It includes motor coupling and coupling guard.

Sys No. : 2 **System : Feed Prep**

Item No.	Equip ID	Qty	Description
5	CENT-1	1	Centrifuge

Motor HP	Elec Load	Weight (lb)	Engineer
200, 40	480 / 3 / 60, 480 / 3 / 60		Craig Smith, FWEC

Envelope Dimension: TBD
Throughput: Design, 60 gpm

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Andritz-Ruthner, Inc.	Kyle DeLon	817-465-5611	817-468-3961

The Centrifuges are used to dewater TTA slurry from its initial 10-30% solids content to 50% solids content. Solids output is directed into the Dryer Screws, liquid output is pumped back to the TTA, and Off-Gas is routed to the FD Fan.

The 200 HP motor drives a variable speed main drive (VFD). The 40 HP motor drives a variable speed backdrive (VFD).

Item No.	Equip ID	Qty	Description
6	CENT-2	1	Centrifuge

Motor HP	Elec Load	Weight (lb)	Engineer
200, 40	480 / 3 / 60, 480 / 3 / 60		Craig Smith, FWEC

Envelope Dimension: TBD
Throughput: With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Andritz-Ruthner, Inc.	Kyle DeLon	817-465-5611	817-468-3961

The Centrifuges are used to dewater TTA slurry from its initial 10-30% solids content to 50% solids content. Solids output is directed into the Dryer Screws, liquid output is pumped back to the TTA, and Off-Gas is routed to the FD Fan.

The 200 HP motor drives a variable speed main drive (VFD). The 40 HP motor drives a variable speed backdrive (VFD).

Item No.	Equip ID	Qty	Description
7	DS-1	1	Dryer Screw

Motor HP	Elec Load	Weight (lb)	Engineer
15	480 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	16,000 Lb/Hr (228.6 CF/Hr)

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Svedala Industries, Inc.	Dave Kleen	719-386-0242	719-471-4469

The Dryer Screw is used to dry the feed from 50% water content to 5% water content. It has a integral scale. One motor drives a reducer/drive unit which drives the multiple screws.

Dryer contains 662 gallons of Dowtherm Q Thermal Fluid. Matl flow rate 16,000 lb/hr, Matl input temp 50 deg F, Hot Oil transfer agent, Fluid input temp 550 deg F, Fluid discharge temp 480 deg F. Total fluid flow 815.4 GPM. Screw fluid volume 538 gal.

Item No.	Equip ID	Qty	Description
8	DS-2	1	Dryer Screw

Motor HP	Elec Load	Weight (lb)	Engineer
15	480 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	16,000 Lb/Hr (228.6 CF/Hr)

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Svedala Industries, Inc.	Dave Kleen	719-386-0242	719-471-4469

The Dryer Screw is used to dry the feed from 50% water content to 5% water content. It has a integral scale. One motor drives a reducer/drive unit which drives the multiple screws.

Dryer contains 662 gallons of Dowtherm Q Thermal Fluid. Matl flow rate 16,000 lb/hr, Matl input temp 50 deg F, Hot Oil transfer agent, Fluid input temp 550 deg F, Fluid discharge temp 480 deg F. Total fluid flow 815.4 GPM. Screw fluid volume 538 gal.

Item No.	Equip ID	Qty	Description
9	HTR-1	1	Thermal Fluid Heater

Motor HP	Elec Load	Weight (lb)	Engineer
1 @ 20 , 1 @ 100	31@@480 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
60VF Exhaust Stack	Circulation Rate 850 gpm

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
GTS Energy, Inc.	Brett Hartley	770-801-8884	770-801-8885

The Thermal Fluid Heating System is used to heat the Dowtherm Q Fluid before it is circulated through the Dryer Screws 1,000 gal expansion tank w/ tank tower. 2,000 gal drain tank. Shell & tube type condensor..

Two coil. 3-pass, forced circulation heat transfer systemm 12.0 MMBtu/hr capacity. Fully modulated burner with combustion air blower and 20 HP motor. FM approved gas train and flame safety system. Thermal Fluid Pump and motor, 100 HP.

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Item No.	Equip ID	Qty	Description
10	HTX-1	1	Heat Exchanger

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
18" Dia x 7' Long	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Enviro-Systems, Inc.	David M. Hensley	423-966-2033	423-966-2038

The Dryer Screw Vapor Heat Exchanger condensates the steam vapor coming off the dryer screws. Condensate goes to the Dryer Screw Heat Exchanger Condensate Hold-up Tank, Tank TK-2.

Shell & Tube-Type Heat Exchanger to condense 10,000 lb/hr steam @ 212 deg F (Approx 1500 GPM water @ 85 deg F), ss type 394 tubes, all other materials carbon steel, ASME Section VIII Div I TEMA "C".

Item No.	Equip ID	Qty	Description
11	IH-1	1	Inlet Hopper with Spreader

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Svedala Industries, Inc.	Dave Kleen	719-386-0242	719-471-4469

The collects the material from the Centrifuge and then feeds it to the Dryer Screw.

Item No.	Equip ID	Qty	Description
12	IH-2	1	Inlet Hopper with Spreader

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Svedala Industries, Inc.	Dave Kleen	719-386-0242	719-471-4469

The collects the material from the Centrifuge and then feeds it to the Dryer Screw.

Item No.	Equip ID	Qty	Description
13	NIT-1	1	Nitrogen Supply System

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	With Detail Design		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	519-885-5513	

The Nitrogen Supply System consists of three nitrogen tanks, pressure gauges, hoses, and a regulator

With exposure to oxygen in the expansion tank at elevated temp, the Dowtherm Q fluid will oxidize. The inert gas blanketing the system on the Thermal Fluid Heater, in conjunction with the Nitrogen Supply System, minimizes oxidation of the thermal fluid.

Item No.	Equip ID	Qty	Description
14	TK-2	1	Condensate Hold-up Tank

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	519-885-5513	

There is one 30,000 gallon Dryer Screw Heat Exchanger Condensate Tank.

Sys No. : 3 **System :** Feed Blending & Storage

Item No.	Equip ID	Qty	Description
15	BM-1	1	Hammer Mill

Motor HP	Elec Load	Weight (lb)	Engineer
15	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Feed Rate 5 TPH

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
M.C. DeGoff Process Equipment Co., In	M.C. DeGoff	901-377-0251	901-377-0368

The Hammer Mill is used to pulverize feed and mix additives prior to storage in the dry feed storage hopper.

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Item No.	Equip ID	Qty	Description
16	DA-1	1	Additive Storage Bin

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	3898	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Storage System	Paul Allen	256-543-2467	256-547-6725

Dry Additive Hopper for CaO. 7' Dia with a useable capacity of 502 CF (Approx 53 tons). Installed outside the building attached to the steel support structure provided by the Dry Feed Hoppers.

3/16" Carbon Steel Plate

Item No.	Equip ID	Qty	Description
17	DA-2	1	Additive Storage Bin

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	3898	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Storage System	Paul Allen	256-543-2467	256-547-6725

Dry Additive Hopper for NaOH. 7' Dia with a useable capacity of 502 CF (Approx 53 tons). Installed outside the building attached to the steel support structure provided by the Dry Feed Hoppers.

3/16" Carbon Steel Plate

Item No.	Equip ID	Qty	Description
18	DA-3	1	Additive Storage Bin

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	5113	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Storage System	Paul Allen	256-543-2467	256-547-6725

Dry Additive Hopper for LiOH. 7' Dia with a useable capacity of 502 CF (Approx 53 tons). Installed outside the building attached to the steel support structure provided by the Dry Feed Hoppers.

3/16" Stainless Steel Plate

Item No.	Equip ID	Qty	Description
19	DA-x	1	Additive Storage Support

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	57018	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Storage System	Paul Allen	256-543-2467	256-547-6725

Steel Support Structure for DA-1, DA-2, and DA-3.

Item No.	Equip ID	Qty	Description
20	DF-1	1	Dry Feed Storage Hopper

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	5528	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Storage Systems, Inc.	Paul Allen	256-543-2467	256-547-6725

The three Dry Feed Storage Hoppers are located on Floor 6. Each is 8' Dia with a usable capacity of 727 CF (Approx 330tons). Together they hold approx 7-days supply of feed for Vortec's Cyclone Melting System.

Constructed of 3/16" Carbon Steel Plate and weigh 5,528 lb each. There is a Structural Steel Support Structure to hold the 3 hoppers that weigh approx 57,018 lbs.

Item No.	Equip ID	Qty	Description
21	DF-2	1	Dry Feed Storage Hopper

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	5528	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Storage Systems, Inc.	Paul Allen	256-543-2467	256-547-6725

The three Dry Feed Storage Hoppers are located on Floor 6. Each is 8' Dia with a usable capacity of 727 CF (Approx 330tons). Together they hold approx 7-days supply of feed for Vortec's Cyclone Melting System.

Constructed of 3/16" Carbon Steel Plate and weigh 5,528 lb each. There is a Structural Steel Support Structure to hold the 3 hoppers that weigh approx 57,018 lbs.

2295

Item No.	Equip ID	Qty	Description
22	DF-3	1	Dry Feed Storage Hopper

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	5528	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Storage Systems, Inc.	Paul Allen	256-543-2467	256-547-6725

The three Dry Feed Storage Hoppers are located on Floor 6. Each is 8' Dia with a usable capacity of 727 CF (Approx 330tons). Together they hold approx 7-days supply of feed for Vortec's Cyclone Melting System.

Constructed of 3/16" Carbon Steel Plate and weigh 5,528 lb each. There is a Structural Steel Support Structure to hold the 3 hoppers that weigh approx 57,018 lbs.

Item No.	Equip ID	Qty	Description
23	FB-1	1	Feed Blender

Motor HP	Elec Load	Weight (lb)	Engineer
40	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

The horizontal ribbon type feeder is located on thr 5th floor.

Features Include: 1) 3/16" T316 ss steel plate body, 46" x 92", 2) 3/8" T316 ss steel end plates, 3)12 ga. Gasketed cover assy, 4) 6" Dia T316 ss steel solid mainshaft w/ a continuous double ribbon agitator, 5) 10" pneumatic actuated slide gate discharge.

Item No.	Equip ID	Qty	Description
24	FH-1	1	Feed Hopper (Included with PSC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Smoot Co.	Jeffery P. Pitts	913-362-1710	913-362-7863

The Feed Hpooer collects the material from Hammer Mill BM-1 and feeds it to the Pneumatic Conveying System PSC-1

Cost included with PCS-1

Item No.	Equip ID	Qty	Description
25	FSS-1	1	Feed Sampling System

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Instrumentation		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Bristol Equipment Company	C.F. Phalen	630-553-7161	630-553-5981

The Feed Sampling System samples the feed between the Pneumatic Conveying System Smoot Dense Phase Transmitter and the Dry Feed Storage Hoppers.

Item No.	Equip ID	Qty	Description
26	MS-1	1	Dry Feed Metering Screw

Motor HP	Elec Load	Weight (lb)	Engineer
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
Approx 4" x 1.5" x 7'-3" Long	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Dry Feed Metering Screw, MS-1, feeds out of the Dry Feed Storage Hopper, DF-1.

Approx 4" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Item No.	Equip ID	Qty	Description
27	MS-2	1	Dry Feed Metering Screw

Motor HP	Elec Load	Weight (lb)	Engineer
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
Approx 4" x 1.5" x 7'-3" Long	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Dry Feed Metering Screw, MS-2, feeds out of the Dry Feed Storage Hopper, DF-2.

Approx 4" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

2295

Item No. **Equip ID** **Qty** **Description**
28 MS-3 1 Dry Feed Metering Screw

Motor HP	**Elec Load**	**Weight (lb)**	**Engineer**
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension: Approx 4" x 1.5" x 7'-3" Long
Throughput: With Detail Design

Potential Supplier	**Supplier Contact**	**Supplier Phone**	**Supplier Fax**
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Dry Feed Metering Screw, MS-3, feeds out of the Dry Feed Storage Hopper, DF-3.

Approx 4" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Item No. **Equip ID** **Qty** **Description**
29 MS-4 1 Dry Feed Metering Screw

Motor HP	**Elec Load**	**Weight (lb)**	**Engineer**
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension: Approx 3" x 1.5" x 7'-3" Long
Throughput: With Detail Design

Potential Supplier	**Supplier Contact**	**Supplier Phone**	**Supplier Fax**
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Dry Additive Meetering Screw, MS-4, feeds out CAO from thr Dry Additives Storage Hopper DA-1.

Approx 3" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Item No. **Equip ID** **Qty** **Description**
30 MS-5 1 Dry Feed Metering Screw

Motor HP	**Elec Load**	**Weight (lb)**	**Engineer**
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension: Approx 3" x 1.5" x 7'-3" Long
Throughput: With Detail Design

Potential Supplier	**Supplier Contact**	**Supplier Phone**	**Supplier Fax**
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Dry Additive Meetering Screw, MS-4, feeds out NaOH from thr Dry Additives Storage Hopper DA-2.

Approx 3" x 1.5" x 7'-3" Long, carbon steel tubular feeder with a 1 HP drive at 25 RPM with a varispeed controller.

Item No.	Equip ID	Qty	Description
31	MS-6	1	Dry Feed Metering Screw

Motor HP	Elec Load	Weight (lb)	Engineer
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
Approx 3" x 1.5" x 7'-3" Long	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Dry Additive Meetering Screw, MS-4, feeds out LiOH from thr Dry Additives Storage Hopper DA-3.

Approx 3" x 1.5" x 7'-3" Long, 316 stainless steel tubular feeder with a 1 HP drive at 35 RPM with a varispeed controller.

Item No.	Equip ID	Qty	Description
32	PCS-1	1	Pneumatic Conveying System

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	Instrumentation		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	4 TPH

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Smoot Co.	Jeffery P. Pitts	913-362-1710	913-362-7863

The Pneumatic Conveying System will convey the feed from the Dense Phase Transporter to one of the three Dry Feed Storage Hoppers. Pipe Grooved in the field by General Contractor. Feed Rate 4 ton/hr (80 CF/Hr), Bulk density 90 lb/CF, Feed Size -35 mesh.

Includes: Surge Hopper, High Level Indicators, Air Cylinder Butterfly Valve, Dense Phase Transmitter, 200 LF Product Concey Line, Product Convey Elbows, Grooved Pipe Couplings, and 2 Sl;ide-type Diverter Valves.

Item No.	Equip ID	Qty	Description
33	SB-1	1	Feed Blender

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
48" Dia x 4' High	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Dynamics, Inc.	Billey D. Quinton, Jr.	770-429-1550	770-429-1571

The 65 CF Surge Bin is located on thr 4th floor. Structural legs provide 6VF (Vertical Feet) clearance below the discharge flange.

Includes: Mac wWork Bin, 65 CF, 48" Dia x 4' straight wall carbon steel construction, all product contact parts. 60 deg hopper, flanged discharge to mate 12" orifice gate. 12" air operated orifice gate.

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Item No.	Equip ID	Qty	Description
34	SC-1	1	Loss-in Weight Feeder

Motor HP	Elec Load	Weight (lb)	Engineer
3/4	180 Volt DC, 110 / 220 / 1 / 60		Craig Smith, FWEC

Envelope Dimension: TBD

Throughput: Feed Rate 2,000 PPH

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Material Dynamics, Inc.	Billey D. Quinton, Jr.	770-429-1550	770-429-1571

The Loss-in-Weight Feeder is used to control the feed rate to the Vortec CRV Reactor in the Vortec Cyclone Melting System (CMS). It provides volumetric metering with gravimetric validation of throughput.

Dry Matl Feeder: 50 CFH, 2.65 CF Tuf-Flex Internal Hopper, 5 CF refill Hopper, Vinyl, Polyethylene and 304 ss construction. Platform Scale: loadcell Capacity (4) 500 lb with summing box, ss and Alum constr.

Item No.	Equip ID	Qty	Description
35	TSC-1	1	Dry Feed Transporter

Motor HP	Elec Load	Weight (lb)	Engineer
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension: Approx 4" x 1.5" x 29'-3" Long

Throughput: With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Transports the Dry Feed from metering screws MS-1, MS-2, and MS-3 to the Blender.

Approx 4" x 1.5" x 29'-3" Long, carbon steel tubular feeder with a 1 HP drive at 16 RPM with a varispeed controller.

Item No.	Equip ID	Qty	Description
36	TSC-2	1	Dry Feed Transporter

Motor HP	Elec Load	Weight (lb)	Engineer
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension: Approx 4" x 1.5" x 31'-9" Long

Throughput: With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Transports the Dry Feed from metering screws MS-4, MS-5, and MS-6 to TSC-3.

Approx 4" x 1.5" x 31'-9" Long, 316 stainless steel tubular feeder with a 1 HP drive at 16 RPM with a varispeed controller.

000364

Item No.	Equip ID	Qty	Description
37	TSC-3	1	Dry Feed Transporter

Motor HP	Elec Load	Weight (lb)	Engineer
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension
Approx 4" x 1.5" x 7'-0" Long

Throughput
With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc	Keith Holt	800-725-7272	817-926-4113

Transports the Dry Feed from TSC-3 to the blender.

Approx 4" x 1.5" x 7'-0" Long, 316 stainless steel tubular feeder with a 1 HP drive at 20 RPM with a varispeed controller.

Sys No. : 4 **System :** Vortec Vitrification System

Item No.	Equip ID	Qty	Description
38	CMS-1	1	Cyclone Melter System (CMS™)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	78.85 KVA		J. Santioanni, Vortec

Envelope Dimension
TBD

Throughput
With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The Cyclone Melter receives preheated batch from the CRV. The gas dynamics within the melter force the batch particles to the wall ehere rapid melting of the preheated batch occurs.

Vitrified product and hot gases exhaust from the melter to the seperator reservoir. This component is a water jackated steel shell of the cyclone melter.

Item No.	Equip ID	Qty	Description
39	CMS-1-1	1	Cyclone Melter System (CMS™) (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	78.85 KVA		J. Santioanni, Vortec

Envelope Dimension
TBD

Throughput
With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The Cyclone Melter receives preheated batch from the CRV. The gas dynamics within the melter force the batch particles to the wall ehere rapid melting of the preheated batch occurs.

Vitrified product and hot gases exhaust from the melter to the seperator reservoir. This component is a water jackated steel shell of the cyclone melter.

2295

Item No.	Equip ID	Qty	Description
40	CMS-1-1	1	CMS™ Refractory Insulation (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the CMS™. The refractory insulation is used between the steel walls and refractory.

Serves to control thermal heat loss between the refractory and steel shell. Also acts to control difference in thermal coefficients between refractory and steel wall.

Item No.	Equip ID	Qty	Description
41	CMS-1-1	1	Hot Gas Piping (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	4000	J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located on the CMS™ tower. The hot gas piping is used to connect various CMS™ components that transport hot gas.

Stainless Steel. Expansion joints are required.

Item No.	Equip ID	Qty	Description
42	CMS-1-2	1	CMS™ Combustion Air Blower (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
40	460V	1200	J. Santioanni, Vortec

Envelope Dimension	Throughput
99.5" x 46" x 42.625"	1974 ICFM

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Provides combustion air flow to the CMS™. Blower is equiped with a variable speed drove to control the combustion air.

000366

Item No.	Equip ID	Qty	Description
43	CMS-1-3	1	CMS™ Spring Hangers (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	2	J. Santioanni, Vortec

Envelope Dimension	Throughput
1/2" to 1-1/4"	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Used to mount the CMS™ to fixed supports to alleviate stress from thermal expansion.

Item No.	Equip ID	Qty	Description
44	CMS-1-4	3	CMS™ View Ports (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
3" OD a 2", 4" OD x 2"	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Used to visually inspect CMS™ safely when operational.

Item No.	Equip ID	Qty	Description
45	CMS-1-5	1	Combustion Air Filter (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	70	J. Santioanni, Vortec

Envelope Dimension	Throughput
6" Dia x 34" long	1974 ICFM

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Used at the inlet of the CMS™ combustion air blower to keep the inlet air clean.

000367

2295

Item No.	Equip ID	Qty	Description
46	CMS-1-7	1	Flame Safety Panel (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	460 V		J. Santioanni, Vortec

Envelope Dimension	Throughput
36" x 36" x 12"	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Controls the flow of natural gas to the roof burners.

Item No.	Equip ID	Qty	Description
47	CMS-1-8	1	CMS™ Refractory (Fired shapes) (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the CMS™ unit. The refractory is used to line and protect the CMS™ during poecessing.

Cast specifically to fit the CMS™.

Item No.	Equip ID	Qty	Description
48	CMS-1-9	1	CMS™ Refractory (Balance) (Included with CMS-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the CMS™ unit. The refractory is used to line and protect the CMS™ steel walls during poecessing.

Generic Industry Standard Shapes.

000368

Item No.	Equip ID	Qty	Description
49	CRV-1	1	CRV Reactor System

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The Counter Rotating Vortex (CRV) Combustor is a well stirred reactor where the combustion and batch preheating occur simultaneously. Natural gas is combusted in the CRV and the premixed batch is injected axially into the CRV.

The batch materials are raised to temperature in the CRV. This component is a water jacketed steel sheel.

Item No.	Equip ID	Qty	Description
50	CRV-1-1	1	CRV Flame Safety Panel (Included with CRV-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	460V		J. Santioanni, Vortec

Envelope Dimension	Throughput
36" x 36" x 12"	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Controls the flow of natural gas to the CMS™.

Item No.	Equip ID	Qty	Description
51	CRV-1-2	1	CRV Natural Gas Control Skid (Included with CRV-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

A pre-piped Skid Assembly that contains the instrumentation and valving required to monitor the total gas flow to the CMS™.

2295

Item No.	Equip ID	Qty	Description
52	CRV-1-3	1	CRV Natural Gas Control Skid (Included with CRV-1-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	4000	J. Santioanni, Vortec

Envelope Dimension	Throughput
126" x 29" x 74"	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

A pre-piped skid assembly that contains the instruments and valving required to monitor the total gas flow to the CMS™.

Item No.	Equip ID	Qty	Description
53	CRV-1-4	1	CRV Refractory (Fired shapes) (Included with CRV-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the CRV unit. The refractory is used to line and protect the CRV steel walls during poecessing.

Cast specifically to fit the CRV.

Item No.	Equip ID	Qty	Description
54	CRV-1-5	1	CRV Refractory (Balance) (Included with CRV-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the CRV unit. The refractory is used to line and protect the CRV steel walls during poecessing.

Generic Industry Standard Shapes.

Item No.	Equip ID	Qty	Description
55	CRV-1-6	1	CRV Refractory Insulation (Included with CRV-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the CRV. The refractory insulation is used between the steel walls and refractory.

Serves to control thermal heat loss between thre refractory and steel shell. Also acts to control difference in thermal coefficients between refractory and steel wall.

Item No.	Equip ID	Qty	Description
56	CRV-1-7	1	CRV Combustor (Included with CRV-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	19800	J. Santioanni, Vortec

Envelope Dimension	Throughput
70" Dia x 120"	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The Counter Rotating Vortex (CRV) *combustor is* a well stirred reactor where the combustion and batch preheat occurs simulataneously. Natural gas is combusted in the CRV and the premixed batch is injected axially into the VRV.

The batch mayreials are raised to melting temperature in the CRV. This component is the water jacketed steel shell of the CRV.

Item No.	Equip ID	Qty	Description
57	CRV-1-8	4	CRV Seismic Restraints (Included with CRV-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	20	J. Santioanni, Vortec

Envelope Dimension	Throughput
16.8" x 5" x 8.31"	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The seismic restraints are used to control lateral movement of the CRV Combustor.

000371

Item No.	Equip ID	Qty	Description
58	SR-1	1	Water Cooled SR System

2295

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	1,228 lb/hr

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The Seperator Reservoir receives the glass from the CRV and then flows into the Drag Conveyor Quench Tank. Hot gases exit the Seperator Reservoir into the Refractory Lined Duct.

The water cooled component is fabricated from steel.

Item No.	Equip ID	Qty	Description
59	SR-1-2	1	Glass Channel Comb. System Blower (Included with SR-1)

Motor HP	Elec Load	Weight (lb)	Engineer
7.5	460V	500	J. Santioanni, Vortec

Envelope Dimension	Throughput
28.5" x 33.5" x 36"	625 ICFM

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Provides combustion air flow to the roof burners. Blower is equiped with a variable speed drive to control the combustion air flow.

Item No.	Equip ID	Qty	Description
60	SR-1-3	6	Glass Channel Comb. System Burner (Included with SR-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
52" x 20" x 12"	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Gas heated system provides extra heat in the glass channel to ensure that glass will not solidify.

Item No.	Equip ID	Qty	Description
61	SR-1-4	1	SR Refractory (Fired shapes) (Included with SR-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the SR unit. The refractory is used to line and protect the SR steel walls during poecessing.

Cast specifically to fit the SRGC.

Item No.	Equip ID	Qty	Description
62	SR-1-5	1	SR Refractory (Balance) (Included with SR-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the SR unit. The refractory is used to line and protect the SR steel walls during poecessing.

Generic Industry Standard Shapes.

Item No.	Equip ID	Qty	Description
63	SR-1-6	1	SR Refractory Insulation (Included with SR-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

Located inside the SR unit. The refractory insulation is used between the steel walls and refractory.

Serves to control thermal heat loss between thre refractory and steel shell. Also acts to control difference in thermal coefficients between refractory and steel wall.

000373

Item No.	Equip ID	Qty	Description
64	VAH-1	1	Air Heater System

2295

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	With Detail Design		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

This system consists of a Air Heater from Stetler & Brinck, Inc. that provides heated air to the CRV reactor, a Refractory Lined Duct from the SR/GC, and a Refractory Lined transfer Duct to the Evaporative Cooler, EC-1.

The Air Heater Assembly consists of a 10 guage steel shell with Control Panel. NEMA 12 enclosure.

Item No.	Equip ID	Qty	Description
65	VAH-1-1	1	Indirect Fired Air Heater (Included with VAH-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	With Detail Design		J. Santioanni, Vortec

Envelope Dimension	Throughput
6' W x 10' H x 7.5' D	2,100 lb/hr. from 60 Deg F - 1,100 Ded F.

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The Air Heater Assembly consists of a 10 ga steel Shell insulated with rigidized fiber blanket refractory. The combustion system is complete with NEPA valve train, electric spark ignition, and high/low control Load control panel NEMA 12 enclosure..

The gas valve train features main gas shutoff valves, ball valve manual gas cocks, gas pressure regulators, vent and pilot selenoids, and high and low pressure switches Prepiped and prewired and complete with a control panel.

Item No.	Equip ID	Qty	Description
66	VAH-1-2	1	Refractory Lined SR/GC Duct (Included with VAH-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		J. Santioanni, Vortec

Envelope Dimension	Throughput
TBD	Flue Gas Flow Rate 2,752 lb/hr

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vortec Corporation	R.K. Hnat	610-489-2255	610-489-3185

The Refractory Lined Duct is between thr SR/GC and the Epaorative Cooler. The duct system includes the transition segment that attaches to the Evaporative Cooler.

The refractory inner lining provides thermal protection to the steel walls.

Item No.	Equip ID	Qty	Description
67	VST-1	1	Structural Steel, CMS™ Tower

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	R. K. Hnat	610-489-2255	610-489-3185

A self contained structural tower that is used to support the Vortec CMS™ System. It also will provide support for the Batch Feed System.

Sys No. : 5 System : Product Handling System

Item No.	Equip ID	Qty	Description
68	C-1	1	Powered Roller Conveyor

Motor HP	Elec Load	Weight (lb)	Engineer
3	460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
57" / 62" W x 20' -0" Long	10 FPM Conveyance Speed

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Conveyor Systems & Engineering, Inc.	Bob LoGiurato	847-593-2900	847-593-2971

The HD Chain-Driven Live Roller Conveyor is used to move the Glass Product Bins into/out of the Product Discharge Area. Conveyor Control System will index the bin to the lid removal stage, progress to the product discharge stage, return for re-lidding.

4.5" Dia x 1.25" thick wall tubing, 2" Dia shaft, 10 FPM Conveyance Speed. First 6' to be modified to allow for Fork Truck to pick-up / deliver Glass Product Bin. Heavy Duty supports at 5' o.c.

Item No.	Equip ID	Qty	Description
69	C-2	1	Powered Roller Conveyor

Motor HP	Elec Load	Weight (lb)	Engineer
3	460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
57" / 62" W x 20' -0" Long	10 FPM Conveyance Speed

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Conveyor Systems & Engineering, Inc.	Bob LoGiurato	847-593-2900	847-593-2971

The HD Chain-Driven Live Roller Conveyor is used to move the Glass Product Bins into/out of the Product Discharge Area. Conveyor Control System will index the bin to the lid removal stage, progress to the product discharge stage, return for re-lidding.

4.5" Dia x 1.25" thick wall tubing, 2" Dia shaft, 10 FPM Conveyance Speed. Heavy Duty supports at 5' o.c.

Item No.	Equip ID	Qty	Description
70	HTX-3	1	Drag Quench Water Heat Exchanger

2295

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	TBD	2655	Craig Smith, FWEC

Envelope Dimension	Throughput
52" L x 27" W x 68" H	125 GPM

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

The Drag-Flight Quench Water Heat Exchanger, HTX-3, is a Water-Water Heat Exchanger used to cool the glass frit.

Similar to Muller Accu-Therm Heat Exchanger Model AT40M HV, F-20 Frame, 315 ss plates, NBR Gaskets, 52" L x 27" W x 68 " H, 304 ss shroud, 130 Degree in, 90 Degree out.

Item No.	Equip ID	Qty	Description
71	HTX-4	1	DF Vapor Heat Exchanger

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	TBD		Craig Smith, FWEC

Envelope Dimension	Throughput
18" Dia x 5' Long	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Enviro-Systems, Inc.	David M. Hensley	423-966-2033	423-966-2038

The Drag-Flite Vapor Heat Exchanger is a Steam Condensor used to cool the steam generated when cooling the glass frit.

Shell & Tube-Type Heat Exchanger. 18" Dia x 5' Long. Condenses 600 lb/hr steam @ 212 Degree F (Approx 100 GPM water @ 85 Degree F). SS type 304 tubes, All other materials carbon steel, ASME Section VIII Div I TEMA "C".

Item No.	Equip ID	Qty	Description
72	JC-1	1	Jib Crain

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
BCH Crain & Hoist. Inc.	Bill Countiss	800-262-0331	205-916-0329

The 1-Ton remotely operated jib crain is located in the product discharge area. It is used to remove/install the lid on the Glass Product Bin.

Jib crain will have a ten foot boom and a one ton wire rope hoist with motorized troiley and remotely controlled.

Item No.	Equip ID	Qty	Description
73	P-9	1	Drag Conveyor Recycle Pump

Motor HP	Elec Load	Weight (lb)	Engineer
15	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Voigt-England Co., Inc.	Buddy Dufau	205-592-9191	205-591-6120

The recycle pump is a peristaltic pump used to transfer the stirred slutty from the TTA Slurry-Hold-up Tank to the centirfuges. This pump may also be used to provide washdown water for cleadout of conveyors, screws, etc.

Item No.	Equip ID	Qty	Description
74	QT-1	1	Quench Tank / Drag Conveyor

Motor HP	Elec Load	Weight (lb)	Engineer
7.5	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
24" W x 20" Long	Approx 1,200 Lb/hr

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Webb-Materials Handling Equipment	Dave Ihrig	770-426-3900	770-426-3919

The Quench Tank with a Drag Conveyor is used to cool the glass and produce frit before the conveyor moves the frit up to drop into the slag bins provided by FDF.

24" W x 2-' L, 5" L horiz water-tight compartment. A 17' long incline at 30 deg slope (Approx 8' discharge height). Opreates at 12 FPM to convey 1.200 lb/hr of glass frit. Two strands of deslagger chain. Overflow weir and Box.

Item No.	Equip ID	Qty	Description
75	SS-2	1	Glass Product Sampling System

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Instrumentation		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Bristol Equipment Company	C.F. Phalen	630-553-7161	630-553-5981

The Glass Product Sampling System samples the 1/16" Fritter Glass Beads output in a vertical drop chute from the Drag Flite Conveyor. Samples to be analyzed in a Laboratory.

Sys No.: 6 **System :** Air Pollution Control System

2295

Item No.	Equip ID	Qty	Description
76	APC-1	1	APC System

Motor HP	Elec Load	Weight (lb)	Engineer
See Components	See Compoments		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	See Compts & Data Sheet 2007-M-DS-008

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

The APC System is a full package from one dupplier that includes: EC-1, P-4A, P-4B, P-5A, P-5B, P-6A, P-7A, P-7B, P-19A, P-10B, S-1, S-2, SMP=1, SMP-2, TK-4, and TK-5.

Item No.	Equip ID	Qty	Description
77	BH-1	1	Dalamatic Dust Collector (Baghouse)

Motor HP	Elec Load	Weight (lb)	Engineer
1	230 / 460 / 1 / 60, 110 / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
DeGroff Process Equipment Co., Inc.	M.C. DeGroff	901-377-0251	901-377-0368

The Dalamatic Dust Collector removes solids from the off-gas stream. Removed solids are recycled to the CMS™. 4 VF clearance under hopper, High Temp Seals, AccuRate Model 602 Volumetric Feeder. Dalamatic reverse jet fabric filter collector.

Envelop style filter bags. 968 SF of 16 oz. Polyester neddlefelt P-84 media suitable for high temp service. Single bank wide housing. 6 tiers of filters. Carbon steel construction w/ baked-on polyester powder finish inside and outside prior to assy.

Item No.	Equip ID	Qty	Description
78	CH-1	1	NOx Scrubber Chiller

Motor HP	Elec Load	Weight (lb)	Engineer
1/2, 5, 3 @ 1, 1 @	480 460 / 3 / 60	4000	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	80 gpm

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Edwards Engineering Corp.	Jorge Mulato	973-836-2800	973-835-2805

The Nox Scrubber Chiller is an Industrial Style Packaged Liquid Chiller that rejects 100,000 BTU/hr @ 25 Degree F LCT.

Features Include: Air cooled unit for outdoor instl, Model No. CE-20AHP, round design, dual pump, 130 gallon reservoir, 80 GPM

000378

Item No.	Equip ID	Qty	Description
79	EC-1	1	Evaporative Cooler (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	With Detail Design		Craig Smith, FWEC

Envelope Dimension	Throughput
2.5' ID x ___ H	5 GPM Max

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

The Evaporative Cooler is a 2.5' ID, 316L ss vessel. Features Include: 316 ss construction, High Density Refractory Lining, Flanged inlet and outlet, 5 GPM max water flow, Automatic liquid flow control.

Item No.	Equip ID	Qty	Description
80	FAN-1	1	Combustion Air Supply Fan

Motor HP	Elec Load	Weight (lb)	Engineer
15	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Charles F. Sexton Compant	Charles Sexton	423-588-9691	423-588-9692

The Forced Draft Combustion Air Fan, Fan-1, is the primary Combustion Air Fan. It is a 500 SCFM Blower

Carbon steel casing, Alum Impellers, carbon steel shaft. Stationary internals, baseplate. Vellumoin/Felt shaft seals, 6" tube ooutlet, 3600 RPM, TEFC motor, Filter - Model No. FIL90011.

Item No.	Equip ID	Qty	Description
81	FAN-2	1	Induced Draft Booster Fan

Motor HP	Elec Load	Weight (lb)	Engineer
2	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
DeGroff Process Equipment Co., Inc.	M.C. DeGroff	901-377-0251	901-377-0368

The Induced Draft fan, Fan-2, is a Booster Fan. It is an American Fan Co. AF Radial Wheel Blower.

Features Include: 316 ss for all airstream contact surfaces, flanged inlet, flanged outlet, drain connection, drive guard system, and variable frequency controller.

2295

Item No.	Equip ID	Qty	Description
82	HTX-2	1	Heat Exchanger

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable	2655	Craig Smith, FWEC

Envelope Dimension	Throughput
52" L x 27" W x 68" H	125 GPM

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Paul Muller Company	Lee Dilthey (FWENC)	423-481-8647	

The Sox Scrubber Sump Water Heat Exchanger is a Water-Water Heat Exchanger used to cool the Sox Scrubber Sump stream.

Similar to Muller Accu-Therm Heat Exchanger, Model AT40M HV, F-20 frame, 316 ss plates, NBR Gaskets, 52" L x 27" W x 68" H, 304 ss shroud, shipping wt. 2,655 lb, 125 G{M, 130 Degree in, 90 Degree out.

Item No.	Equip ID	Qty	Description
83	P-10A	1	Oxidizing Zone Recycle Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Oxidizing ZoneRecycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Item No.	Equip ID	Qty	Description
84	P-10B	1	Oxidizing Zone Recycle Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Oxidizing ZoneRecycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

000380

Item No.	Equip ID	Qty	Description
85	P-3	1	Water Hold-up Tank Pump

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	120 / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

The Water Hold-up Tank Pump provides water to the Evaporative Cooler.

Item No.	Equip ID	Qty	Description
86	P-4A	1	SOx Scrubber Sump Recycle Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Sox Scrubber Sump Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Item No.	Equip ID	Qty	Description
87	P-4B	1	SOx Scrubber Sump Recycle Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Sox Scrubber Sump Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

2295

Item No.	Equip ID	Qty	Description
88	P-5A	1	NOx Conditioner Sump Recycle Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A NOx Conditioner Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Item No.	Equip ID	Qty	Description
89	P-5B	1	NOx Conditioner Sump Recycle Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A NOx Conditioner Recycle Pump. Features Include: Fybroc or equivalent. Single stage centrifugal. FRP Casing, Impeller. Mechanical Seal. Close coupled motor. 1600 RPM.

Item No.	Equip ID	Qty	Description
90	P-6A	1	Urea Injection Pumps (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	120 / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Urea Injection Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

000382

Item No.	Equip ID	Qty	Description
91	P-6B	1	Urea Injection Pumps (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	120 / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Urea Injection Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

Item No.	Equip ID	Qty	Description
92	P-7A	1	Caustic Storage Tank Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	120 / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Caustic Storage Tank Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

Item No.	Equip ID	Qty	Description
93	P-7B	1	Caustic Storage Tank Pump (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	120 / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A Caustic Storage Tank Pump. Features Include: Electronic Metering. Solenoid Driven. PVC Head, TFE diaphragm construction. Microprocessor based pH controller. pH sensor to tank insertion.

2295

Item No.	Equip ID	Qty	Description
94	S-1	1	SO2 Scrubber (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

The SO2 Scrubber Includes internal Recirculation Tank, Flanged inlet and outlet.

Item No.	Equip ID	Qty	Description
95	S-2	1	NOx Scrubber (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

The Nox Scrubber includes FRP Construction, Flanged at both ends.

Item No.	Equip ID	Qty	Description
96	SMP-1	1	Sump Recirculation Tank (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A 1,000 gallon FRP recirculation tank with a covered top.

Item No.	Equip ID	Qty	Description
97	SMP-2	1	Sump Recirculation Tank (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A 1,000 gallon FRP recirculation tank with a covered top.

Item No.	Equip ID	Qty	Description
98	TK-3	1	Radon Degasification Tank

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

A 1,000 gallon polyethylene Radon Degasification Tank.

Item No.	Equip ID	Qty	Description
99	TK-4	1	Urea Storage Tank (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A 1,000 gallon polyethylene tank with a covered top and a agitator.

2295

Item No.	Equip ID	Qty	Description
100	TK-5	1	Caustic Storage Tank (Incl w APC-1)

Motor HP	Elec Load	Weight (lb)	Engineer
TBD	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TurboSonic Inc.	Ron Dawe	519-885-5513	519-885-6992

A 1,000 gallon polyethylene tank with a covered top and a agitator.

Item No.	Equip ID	Qty	Description
101	TSC-4	1	Baghouse Transfer Screw

Motor HP	Elec Load	Weight (lb)	Engineer
1	___ / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
4" x 1.5 " x ___ L	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Hayes & Stolz Industrial Mfg. Co., Inc.	Keith Holt	800-725-7272	817-926-4133

Transports the Bag-house solids to the CMS™ recycle input hopper (Hopper supplied by Vortec). It is a 4" x 1.5" x ___ L ss tublar screw frrder with a 1 HP drive at ___ RPM with varispeed controller.

The transfer screw moves material from near ground level outside the building into the building and up to the third floor. Material has to be moved approximately 35 LF horizontally.

Sys No.: 7 **System:** Water Treatment System

Item No.	Equip ID	Qty	Description
102	SS-1	1	Water Sampling System

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Instrumentation		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Bristol Equipment Company	C.F. Phalen	630-553-7161	630-553-5981

The Water Sampling System samples the output of the Water treatment Package for later Laboratory Analysis.

Item No.	Equip ID	Qty	Description
103	WT-1	1	Water Treatment Package

Motor HP	Elec Load	Weight (lb)	Engineer
3/4, 2 @ 1/2, 1/4	4 @ 110 / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	Input Flow Rate 3.8 gpm

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
L.C. Hammock Co.m Inc.	Dave Turner	423-671-0950	423-671-0950

The Waste Water treatment System is an Alert 2000 Packaged Compact Treatment System. It is skid mounted with carbon steel construction.

Includes: Model 100-WT capable of processing 20 GPM. Filterpress, seld-containedautomated chemical conditioning and suspended solids separation system, lift station, chemical neutalization, flocculation, liquid solid separation and dewatering.

Sys No.: 8 **System: Instrumentation & Control**

Item No.	Equip ID	Qty	Description
104	I&C-1	1	I&C (PLC Programming)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
N/A	Not Applicable

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

LS estimate for I&C Equipment and 350 hours for Programming & PLC Operation included with Installation Cost.

Sys No.: 9 **System: BOP, Other Process Equip**

2295

Item No.	Equip ID	Qty	Description
105	AC-1	1	Air Compressor

Motor HP	Elec Load	Weight (lb)	Engineer
75	460 / 3 / 60, 120 / 230 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	360 cfm

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Gardner Denver, Inc.	J.R. (Jim) Morton	423-577-3961	423-573-3607

Provides clean, dry, compressed air to: Bag-house, Feed Sampling System, Glass Product Sampling System, Water Sampling System, Radon Degasification System, Emergency Water Tank, APC Package, Pneumatic Conveying System, Instrumentation, Miscl. Air Usage.

Features Include: 360 cfm at 100 psi, lubricated rotary screw, air cooled, direct motor drive, modulating vertical inlet valve, skid-mounted, moisture seperator and trap, air dryer, 240 gallon air reserve.

Item No.	Equip ID	Qty	Description
106	BOP-x1	1	Radon Control System Duct

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

For the base estimate, there are no changes to the existing Radon Control System (RCS) Equipment. Approximately 300 LF of duct has to be run from the new Commercial Scale Cyclone Melting System Building to the existing RCS Building.

Item No.	Equip ID	Qty	Description
107	BOP-x2	1	Viewing Portal

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

Viewing portal is in the wall behind the Glass Product Discharge Area and the End Product Handling Area. The forklift Operator uses the portal to view the lid removal operation.

Item No.	Equip ID	Qty	Description
108	BOP-x3	1	Electrical (with Instrumentation)

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

Includes electrical for Service entrance, Electric Equip., Emergency System, Building Grounds, Lighting & Misc Power, Site Office & Storage,

No Installation Cost Included

Item No.	Equip ID	Qty	Description
109	BOP-x4	1	Process Buildings

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
FWENC	Lee Dilthey (FWENC)	423-481-8647	

Includes mandoors & hardware, F&I, Galv stairs, railings, etc

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Item No.	Equip ID	Qty	Description
110	BOP-x5	1	Control Room Furnishings

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
TBD	Lee Dilthey (FWENC)	423-481-8647	

Furnishings for the control room.

2295

Item No.	Equip ID	Qty	Description
111	BOP-x6	1	Process Piping

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	Not Applicable		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
FWENC	Lee Dilthey (FWENC)	423-481-8647	

Includes 12" Dai piping , 8" Dia piping, 4" Dia piping, 2.5" Dia piping, 2" dia piping, 1.5" Dia Piping, 1" dia Piping, and 1/2" dia Piping.

90 degree bends, 45 degree bends, Tees, Flanges, Gate valves, Check valves, solenoid valves, ball valves, reducers, threaded caps, Pneu Oper ContV are also included.

Item No.	Equip ID	Qty	Description
112	CT-1	1	Cooling Tower

Motor HP	Elec Load	Weight (lb)	Engineer
40, 20	2 @ 460 / 3 / 60	10021	Craig Smith, FWEC

Envelope Dimension	Throughput
11'-10" L x 19'-10" W x 13' H	875 GPM

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Fergusen Equipment Co.	Tom ____	423-524-1491	423-637-8304

Cooling Tower CT-1 is a Plate Heat Exchanger designed to reject 9,000,000 BTU/hr.

875 GPM, 125D-85D-78 Degrees. Operating weight 21,834 lbs, 12" 12 blade fan, 6" inlet/outlet connections, 316 ss plates on the APC Condensor.

Item No.	Equip ID	Qty	Description
113	O2-1	1	Oxygen Enrichment System

Motor HP	Elec Load	Weight (lb)	Engineer
N/A	120v 15a / 1 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Air Products and Chemicals, Inc.	Scott B. Sclleicher	864-967-9010	864-967-7249

The Oxygen Enrichment System provides additional oxygen to Vortec's CMS™ combustion air.

Actual equipment will be supplied by Air Products and Chemicals, Inc. Air Products and Chemicals, Inc. will charge $0.40/scf of liquid oxygen used.

Item No.	Equip ID	Qty	Description
114	P-11	1	Washdown Return Water Pump

Motor HP	Elec Load	Weight (lb)	Engineer
15	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Voigt-England Co., Inc.	Buddy Dufau	205-592-8191	205-591-6120

The maintenance Washdown Return Pump is identical to the Holding Tank transfer Pump. A peristaltic pump used to return washdown water back to the TTA.

Item No.	Equip ID	Qty	Description
115	P-8	1	Cooling Tower Pump

Motor HP	Elec Load	Weight (lb)	Engineer
20	460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	875 GPM

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Fergusen Equipment Co.	Tom ____	423-524-1491	423-637-8304

The Cooling Tower Pump has a split case. 875 GPM @ 100' TDH, non-overload.

Item No.	Equip ID	Qty	Description
116	TK-6	1	Washdown Water Return Tank

Motor HP	Elec Load	Weight (lb)	Engineer
1.5	230 / 460 / 3 / 60		Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	With Detail Design

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Rodgers-Turner & Associates	Leonard M. Barger	423-894-2958	423-899-6874

The 8,000 gallon FRP Washdown Water Return Tank with integral in-tank mixer is identical to the transfer Tank Area (TTA) Slurry Hold-up Tank with integral in-tank mixer.

The tank is an above ground 8,000 gal. Filament wound reinforced thermoset plastic vessel mfg. Per ASTM D-3299-95a. It has an inner corrosion liner fab w Osophthalic Polyester Resin. Flat bottomed with a dish head. Includes integral mixer.

000391

F 2295

Item No.	Equip ID	Qty	Description
117	VAC-1	1	HEPA Filter Vacuum

Motor HP	Elec Load	Weight (lb)	Engineer
50	460 / 3 / 60	2360	Craig Smith, FWEC

Envelope Dimension	Throughput
TBD	6 tons/hr

Potential Supplier	Supplier Contact	Supplier Phone	Supplier Fax
Vector Technologies, LTD.	Bret Alexander	414-247-7411	414-247-7110

The mobile HEPA filtered vacuum is for evacuating dry feed components. The vacuum is transportable to location needed.

150 lf 4" hose, drum filter/ stand assy, drum loader, wheel mounted, integrated 2 CY Hopper.

000392